Explorer's Guide to
COMMODORE® LOGO

Joan Moscovitch Webb, Peter von Mertens,
Maggie Neville Holmes

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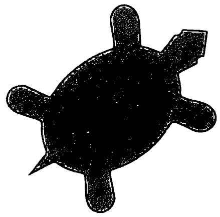

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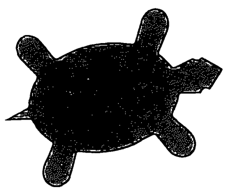

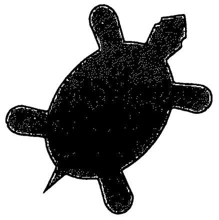

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EQUIPMENT NEEDED

1. A Commodore 64
2. A monitor or television (color recommended) with adapter
3. One disk drive
4. Commodore Logo
5. A blank disk
6. Printer (optional)

To Tom, Page, and Maurice

Preface

At the time we are writing, the Logo language for micro-computers is relatively new, so you may know little about it and have little experience with it yourself. Some background information will help you.

Logo is a graphic language. Actually, Logo (as a derivative of LISP, the language of artificial intelligence) is a full computer language and can be used for calculations, manipulation of words, writing music, and so forth, as well as for graphics. In this book, however, and for beginners in general, just the graphic aspect of Logo is explored.

Logo is an interactive language. This means that you get immediate feedback from the computer. You can see the results of your commands right away. Errors in notation are answered by Logo messages, which give information about each error. The graphic pictures also give immediate feedback.

Logo is procedural. The basic element of Logo is called a procedure and is a set of Logo instructions. Users make up definitions for new procedures and teach them to the computer. For example, you can teach a computer how to draw a square. From then on, the computer will draw that square whenever you give the command.

The procedures become building blocks for creating more and more complicated pictures. A letter S repeated many times may make a star pattern. A trapezoid with little circles for wheels may look like a truck.

Procedures naturally lead to good problem-solving techniques. Large, complex problems can be broken down into smaller, easily handled ones.

Because Logo was designed to promote a specific type of learning, people often speak of the ''Logo philosophy.'' The key elements in this philosophy are that children should be actively involved in their learning, that they progress from concrete to abstract thinking, and that their environment should be inherently interesting to them and naturally encourage exploration and problem solving. *Explorer's Guide to Commodore Logo* implements this Logo philosophy.

Acknowledgments

We have had a lot of fun writing this book, just because almost anything related to Logo is fun. The inevitable hard work that goes into writing a book was eased by the help we received from many people.

Several teachers tested our activities in their classrooms and provided invaluable comments and suggestions. These teachers include: Leah O'Mahony and Judith Wilson, The Gordon School, East Providence, RI, Betty Schlenker, Fisher School, Foxboro, MA, and Cheryl Larsen, Hosmer/East School, Watertown, MA. Special thanks go to Cheryl for giving us permission to use the Haunted House maze created by her students.

We are grateful to Ricky Carter, Lesley College, Cambridge, MA, and Louisa Birch, Meadowbrook School, Weston, MA, for reading our manuscript and giving constructive criticism.

Our thanks go to all the students, ages 8–50, with whom we have worked in our Logo classes. We have selected samples of their work to include in the book. Any names mentioned in the text belong to these students. Most of their work is just as they created it, although we have altered procedures in a few cases. We thank all our students for their enthusiasm and for inspiring us to write the book.

Joan

Peter

Maggie

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CHAPTER

ONE

Introduction

Chapter One

What This Book Is About

You are about to begin an adventure. Imagine that you are sailing to a chain of islands in the Pacific Ocean. The purpose of the trip is to explore the islands and learn all you can about what is there: mountains, rivers, volcanoes, birds, other animals, flowers, and trees.

You wonder what you can expect to find there. Where should you go first? Where are the rivers? What would be the best place to look for birds or flowers? You obviously need a map of the group of islands. (See picture.) Now you can see where the rivers and mountain ranges are. You can at least tell how to land your boat at the mouth of a river and follow the river inland to the mountains. To learn more, you'll have to go there and climb the mountains yourself.

You will also want to take along a book with information about the main features you will find there. For example, since it is a warm place, you will want information about tropical birds and plants.

Sailing to the islands is a little like learning about Logo. In both cases you are an explorer, discovering for yourself new, exciting things. Our book will be a guide for you, like the map and information about the islands. The map can show you where an important mountain or river is, but it's still up to you to explore the river or to climb the mountain. In this book, we will tell you important information about Logo and give you starting places for your explorations. Then it will be up to you to be an explorer and make your own discoveries.

Chapter One

While working with Logo, you will want to keep a record of what you're doing, just as you would keep a travel diary during your trip to the islands. Besides being a guide to Logo, this book will become a kind of journal and a sketchbook, too. It has plenty of space for you to write about what you do and to draw sketches of what you have seen and created yourself. Later, you will be glad to have this book to remember your good times.

How to Use This Book

You will probably not go through this book by starting on page 1 and going in order to the last page. Sometimes you may want to jump ahead to read about something you find you need to know. Often you will want to go backwards to refresh your memory about how to do something. This book includes reference pages in the main part and charts in the back to help you find what you need to know. The reference pages have special colored borders to make them easy for you to find.

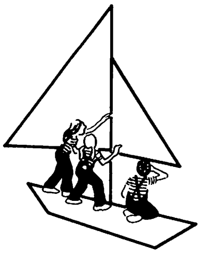
Most likely you won't try all our suggested activities. Just as it would be impossible to see and do everything there is to see and do on the islands, it is impossible to see and do everything you could do with Logo. No guide book to the islands can tell you all there is to see and do; our guide book can't tell you all you can do with Logo. It is simply too rich and fascinating, and you will surely think of things on your own that we did not think of. We have marked the most important activities with a key, 🔑 . The key activities will help you understand ideas that you will need later in the book.

Throughout the book, we have tried to tell you about the most interesting things to do, and to show you the best starting places for your own explorations. We hope you will take time to experiment on your own. Even if you can't do every activity in the book, take your time. If you rush, you will miss the fun and excitement of Logo.

A Note for People with Computers at Home

If you have bought this book to use at home instead of at school, you will probably need some help from an adult or an older friend or brother or sister. Just as traveling is usually more fun with a companion, so are the activities in this book. Invite a friend or two over, or do the activities with someone in your family.

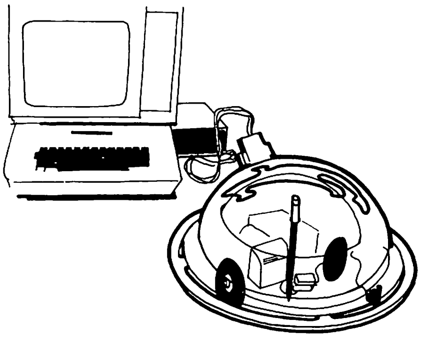
Your advantage at home is that you have a computer to yourself whenever you want it and for as long as you want it. You can use that advantage to spend lots of time exploring Logo.

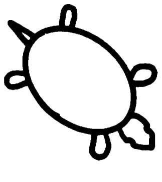


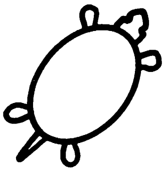
CHAPTER

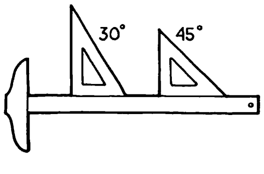
TWO

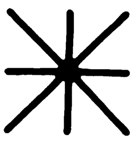
Activities Without the Computer











Chapter Two

What a Computer Is and Does

Think for a little while of yourself at a big family picnic on a fine summer day. As you sit down to the picnic table, you receive a lot of information. Your eyes see and your nose smells all the food in front of you. Unfortunately, you can't eat all of it; you have to make some choices. You also remember other picnics you've been to; you have even more information from them already stored in your mind.

Your eyes tell you, ''There's some of Aunt Sue's potato salad. It looks great.'' Your memory says, ''Oh, I had it last year, and it was too mushy.''

So you decide to eat potato chips this year, and you put some on your plate.

Cousin Jack's apple pie looks tempting, and you remember it tastes terrific every year. You take a piece of pie.

Chapter Two

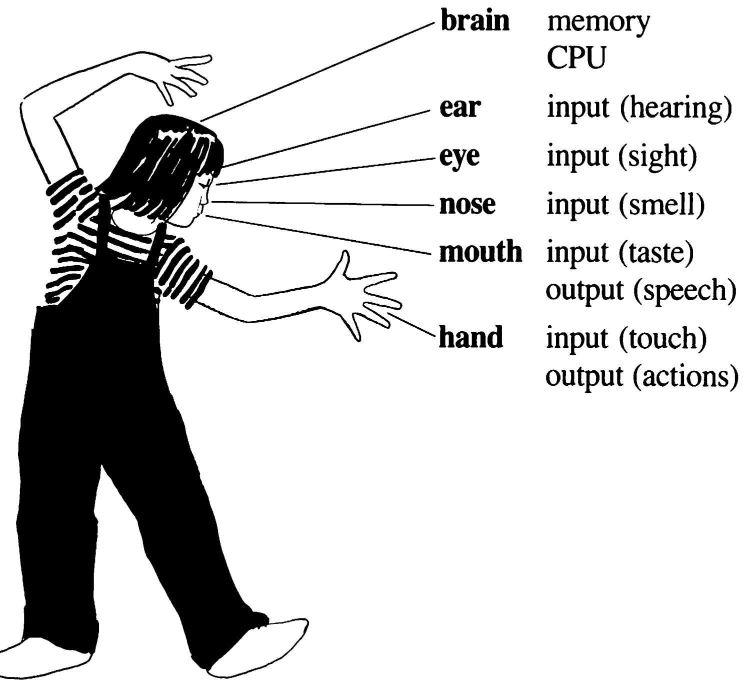
The Structure of Computers

At the picnic, you are using your senses and your brain to act on information you receive. In a similar way, computers also take in information and work with it. All computers—no matter how big or small—are organized into three main parts:

Memory	This is the place where a computer stores information. Bigger computers have bigger memories.
Input/Output	These are devices for putting information into the computer and getting it out.
Central Processing Unit (CPU)	This is the director, or the part of the computer that is in charge of the computer's operation.

In the case of the picnic, your eyes and nose are your Input devices. They take in information. The Output device is your hand as it takes potato chips and apple pie. Your memory of food in other years is like the Memory of a computer. Finally, your brain oversees everything that happens as you take in information and take actions. Your brain acts as the Central Processing Unit, or the CPU.

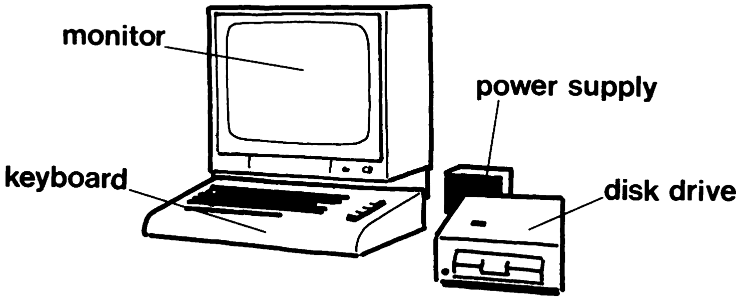
Memory	brain	storing information from other picnics
Input/Output	input: output:	coming in through the five senses. through talking, acting, writing, reaching, eating
CPU	brain	controlling everything you do


brain memory CPU
ear input (hearing)
eye input (sight)
nose input (smell)
mouth input (taste) output (speech)
hand input (touch) output (actions)

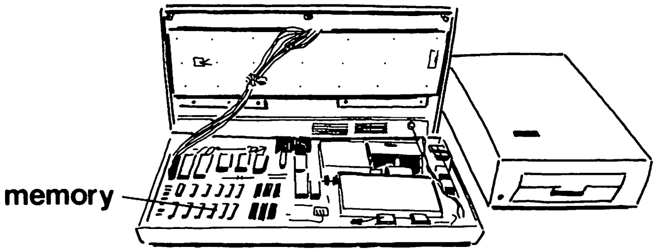
Structure of the Commodore 64 Computer

The Commodore 64 computer that you will be using has the same three-part structure as other computers. Look at the pictures below or at your own Commodore 64 to see the three main parts.

Memory	This consists of rows of small black boxes, called *chips*, inside the main case. Information is stored here temporarily while the computer is on. To store information more permanently, you will be using disks.
Input/Output	These devices include keyboards, monitor screens, printers, and disk drives. You type in information at the keyboard. Information comes out on the monitor screen (looks like a TV and may even be one) and also on a printer (if you have one). The disk drive moves information back and forth between memory and the disk.
CPU	This is the big chip inside the main case. The chip has a very complicated maze of electronic circuits.



The Commodore 64 Computer



Inside of the Computer

Chapter Two

Languages

Modern computers store information in the form of electrical current. We are familiar with electrical current in lights. When a light is on, the current is on; when a light is off, the current is off. Sometimes we can get information from lights. For instance, if we see a light on at 11:30 P.M. in someone's bedroom, we figure that the person is still awake. A dark house with no lights on at all tells us that the people either are not home or are all asleep.

People have invented a code, made up of 0's and 1's, to communicate with the computer. A zero (0) means the current is off; a one (1) means the current is on. The CPU can understand this code. Various combinations of 0's and 1's have special meanings. For example,

```
1000 0110
```

means put a number into a certain place in the computer's memory.

Instructions in the code of 0's and 1's make up *machine language*. That is the only language that computers understand. But it is hard for us to read and write 0's and 1's, and it would be easy for us to make a lot of mistakes if we wrote instructions in that code. We need to give instructions that the computer can understand but that are still like English. Logo is a language that translates English into the computer's machine language code of 0's and 1's. The computer can understand it, and so can we. In fact, as you will see, Logo is easy to understand and use.

Logo as a Language

We can think of Logo as starting out as a small language with only about a 30-word vocabulary. Here are some of the beginning words or commands:

FORWARD
BACK
LEFT
RIGHT
DRAW
HIDETURTLE
SHOWTURTLE
PENUP
PENDOWN

Note: Throughout this book, Logo commands, like those above, are written in capital letters.

First, you will learn what these words mean and how to use them. For example, HIDETURTLE hides the turtle and makes it invisible. Then you will learn how to add your own words to the Logo language. As you add more and more words to Logo, you can teach the computer to do more and more interesting things.

Chapter Two

To get the computer to do what *you* want, you have to give the computer a set of Logo instructions. That set is called a *procedure*. Without a procedure, the computer does nothing.

You are going to be in control of the computer. You will type in Logo instructions at the keyboard as Input. The computer's CPU will take that Input, translate it into machine language, and do what you have told the computer to do. The Output will be a picture or a written message, and you will check the Output to see if it's what you wanted.

Things to Think about:

Why are machine language instructions in 0's and 1's?

Where is the Commodore 64's memory? What does it look like?

How is the disk drive attached to the Commodore 64? Why does it have to be attached?

Why do you have to plug in a computer?

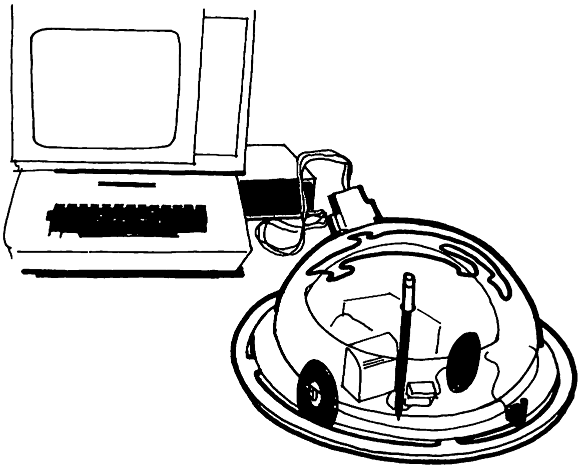
Is the monitor screen attached to the computer?

How do you learn a foreign language? What would be some beginning words?

What other kinds of codes can you think of?

Can a computer think?

Chapter Two



Introducing the Turtle

Logo language can be used to run a special robot, called the turtle. The original turtles are like big mechanical toys. (See picture.) They were designed to show you the results of your instructions to the computer. You have to tell the turtle what to do; it doesn't do anything by itself.

In the beginning, the turtle robot understands only a few commands. The most important ones are:

FORWARD, BACK, RIGHT, and LEFT

With just these four commands you can get the turtle to move in many ways.

FORWARD	means walk forward.
BACK	means walk backward.
RIGHT	means rotate to the right (the turtle's right). The turtle turns in place, without moving forward or backward.
LEFT	means rotate to the left (the turtle's left) without moving forward or backward.

The turtle can move around the floor. It has a pen that can be put up or down. When the pen is down and the turtle moves, the turtle draws a line on paper underneath it on the floor. Some turtles have lights and bumpers and beepy voices. You can teach them to sing a tune or walk until they bump into something, but in this book we are only going to teach the turtle how to draw.

Chapter Two

An important thing to know about the turtle is that *you* can act just like it. If you walk on fresh snow or walk with muddy feet, you draw as you walk, just like the turtle. (See picture.) When you act like the turtle, though, you have to pretend to be a robot instead of a person. That means you can do only what you are told—no more and no less. You can't do what *you* want, only what you're told. You have to act like a machine. Right now, as a turtle robot, you only understand four commands.

ACTIVITIES

Choose a partner. Take turns being "turtle" and "commander." Instruct the turtle to move FORWARD a certain number of steps, such as FORWARD 5 or FORWARD 8. In this book we will write FORWARD {number of steps}. Use these commands only:

FORWARD	{number of steps}
BACK	{number of steps}
RIGHT	{amount}
LEFT	{amount}

Note: Throughout this book, we will put curly brackets { } around quantities that can vary, such as a number of turtle steps or an amount to rotate.

Remember, RIGHT means to the turtle's right; LEFT means to the turtle's left. The turtle rotates in place and *does not* move forward or backward. It stands in the same spot but faces a different way.

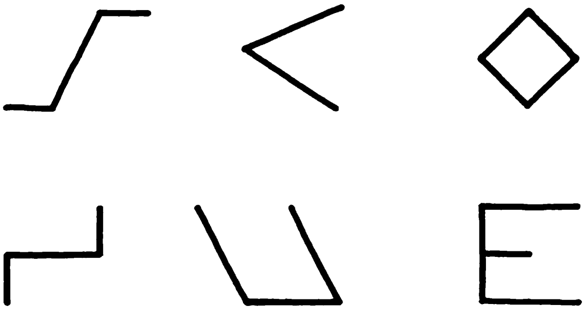
When using the RIGHT and LEFT commands, we will just say "RIGHT a little" or "LEFT a lot" for the time being. As you work with your partner, try to find better ways to describe the turn you want.

Here are some examples of command sequences. Start with these, and then make up your own.

a. FORWARD 2, RIGHT a lot, FORWARD 2, BACK 4.

b. BACK 2, LEFT a little, BACK 2, LEFT a little, BACK 2, LEFT a little, BACK 2.

1. Try directing the "turtle" to walk paths like these. Make up your own shapes too.



2. Give the "turtle" a command it doesn't know, such as Hop. (Remember it only knows FORWARD, BACK, RIGHT and LEFT.) What do you think would happen? If you were the "turtle," what would you do? Compare your answers to others in the class.

3. What would happen if you told the "turtle" FORWARD 500. "Turtle," would you keep walking no matter what?

4. Give the "turtle" these commands:

LEFT a lot
LEFT a lot
LEFT a lot

"Turtle," what happens to you? Would you keep going as long as your "commander" tells you to?

5. Switch roles again and discuss 2–4 again.

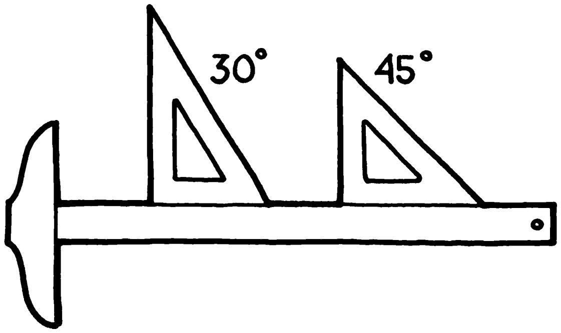
Chapter Two

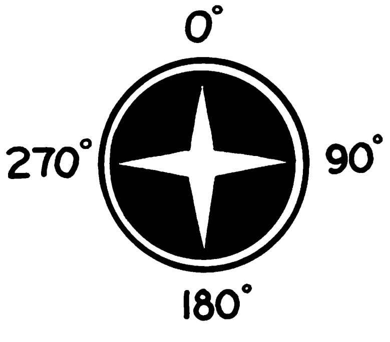
Degrees

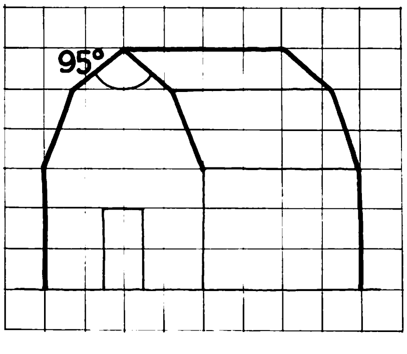
When you give turning directions to the turtle at the computer, you will have to be more definite than "RIGHT a little" or "LEFT a lot."

The turtle expects a number after the RIGHT and LEFT commands. That number is how many *degrees* the turtle will turn. Degrees are units to measure how big a turn is, just as steps or inches are units to measure distance along a straight line. The bigger the number of degrees, the further the turtle will rotate.

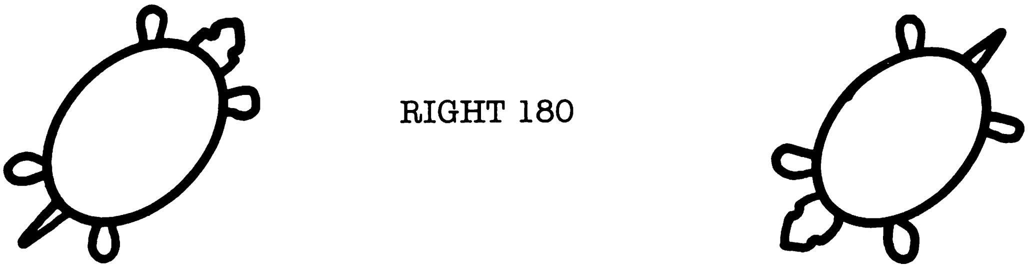
People all over the world use degrees in many activities, including map-making, navigation, and architecture. (See figures.)







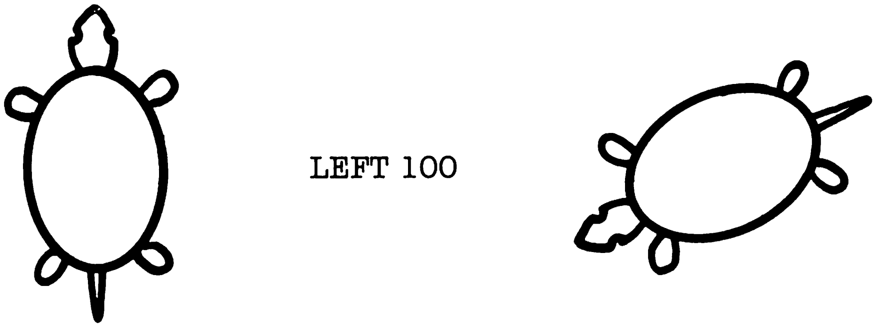
Everyone has agreed that 0 degrees means no turn at all and that a 360-degree turn is one complete rotation. If you tell the turtle to turn left 360 degrees (360°), it will turn left all the way around and end up exactly where it started. Since 180 is half of 360, a 180-degree turn is an about-face. A RIGHT 180 command would make the turtle turn right until it faces the opposite direction from where it started.

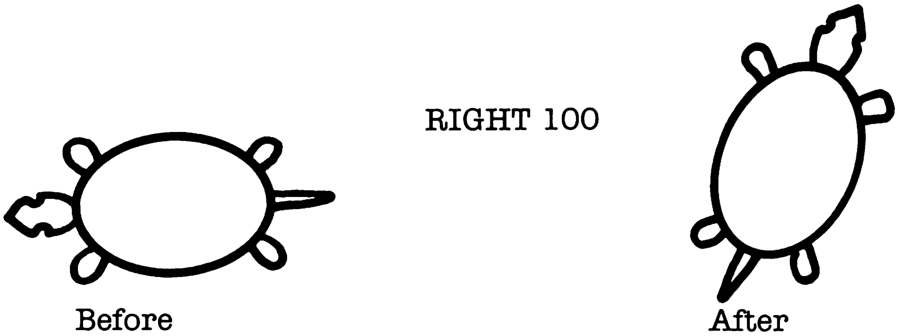


The turtle always turns to *its* right for a RIGHT command or to *its* left for a LEFT command. Sometimes a RIGHT command will make the turtle move toward *your* left. That can be confusing, but just remember that the turtle only knows about itself and *its* own right.

The turtle will always turn relative to where it is when you give the command. When the turtle turns, it rotates in place. Its pen does not draw at all.

Examples:





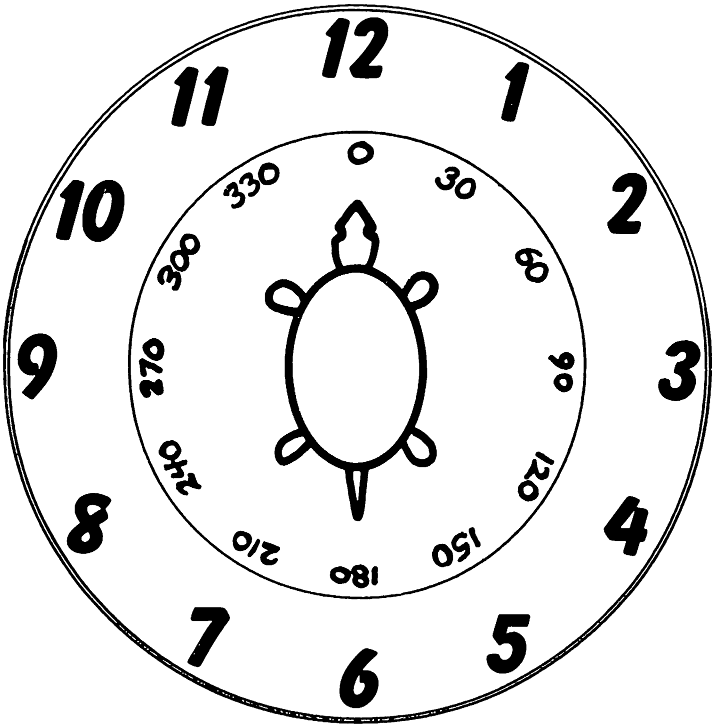
Chapter Two

In the Air Force, pilots use the numbers on a clock to help them judge the position of another plane. You can also use a clock to help you learn the number of degrees in various turns.

To make a Turtle Clock, you will need:

the Turtle in Appendix F on page 245
the Clock Face and the Degree Circle on pages 243 and 245 in Appendix F
1 index card
2 pieces of cardboard 8″ × 10″
a 1″ paper fastener
a pair of scissors
red and green markers, crayons, or pencils
glue or paste

1. Glue the Turtle to the index card and cut out the Turtle.
2. Glue the Degree Circle and the Clock to the pieces of cardboard and cut them out.
3. With the red marking pen, trace over the outer numbers on the Degree Circle.
4. With the green marking pen, trace over the inner numbers on the Degree Circle.
5. Insert the paper fastener through the Turtle, the Degree Circle and the Clock. Spread the tips of the fastener.
6. Your finished Turtle Clock should look like the one shown below.



The Turtle Clock you just made will help you in the activities below. Note that there are 30° between each hour.

The red numbers on the degree circle show the number of degrees you turn toward the right. Red is for Right.

The green numbers show the number of degrees you turn toward the left. Green is for Left.

ACTIVITIES

RT stands for RIGHT; LT stands for LEFT.

The degree (°) sign is omitted when a command is written.

6. Line up the 0 on the degree circle with 12:00. Turn the turtle to face the hours below. How many degrees did you move the turtle? Reset the turtle to 12:00 after each move.

a. 4:00 ____________________

b. 7:00 ____________________

c. 10:00 ____________________

7. To which hour is the turtle pointing after it makes these moves? Reset to 12:00 after each new move.

a. RT 60 ____________________

b. LT 90 ____________________

c. RT 300 ____________________

8. In this exercise, the turtle will make a series of turns. After each turn, you have to start measuring the new turn from 0, just as you start from 0 on a ruler. To do that, move the degree circle—*not* the turtle or the clock—so that 0 is again at the turtle's head after each turn. The turtle always starts a turn pointing to 0; the clock numbers always stay in the same position.

Toward which hour is the turtle heading after it makes each of the series of moves below? Reset to 12:00 before each new series.

a.	b.	c.
RT 30	LT 90	RT 30
RT 30	RT 90	LT 90
RT 30	LT 90	RT 210
_____	_____	_____

🔑 **9.** Which one move will get you to the same place as LT 270?

10. Start with the turtle heading toward 4:00. How many more degrees does it have to move to head toward 7:00?
RT

or LT

🔑 **11.** You have just moved the turtle RT 210. How much more to the right should you move it to make it head toward 0?

🔑 **12.** Can you figure out where the turtle ends up after this series of turns? Start with the turtle pointing towards 12:00.

RT 60
RT 60
RT 60
RT 60
RT 60
RT 60

How did you figure out your answer?

How many RT 90 commands would get the turtle to the same place?

13. Starting with the turtle at 12:00, find three ways to get the turtle to head toward 5:00. You can make more than one move.

Can you think of more than three? ______________________________

What is the longest way you thought of? ______________________________

What is the shortest way? ______________________________

14. What is the difference between RT 180 and LT 180?

15. From your work with the clock, you have become familiar with degrees. Some turns are used so often that they have been given names. A 90° turn is called a right angle. Ninety-degree angles are everywhere, such as the corner of a door. Can you find some in your room? List them here:

Challengers

16. The turtle starts facing 12:00 and moves RT 45. Between what two hours is it heading?

17. What do the red and green numbers add up to at:

a. 3:00 ____________________

b. 5:00 ____________________

c. 11:00 ____________________

Is the answer always the same? Why or why not?

Chapter Two

Turtle Drawing on the Floor

You are now able to act like the turtle by moving a given number of steps and by turning a given number of degrees. The turtle, however, can also draw. What you need now is a pen.

There are two ways to imitate the turtle's pen when you are working on the floor. If you have carpets or rugs, you may use chalk. (Check with your teacher or parent first.) The chalk should rub out of the rug or vacuum up fairly easily.

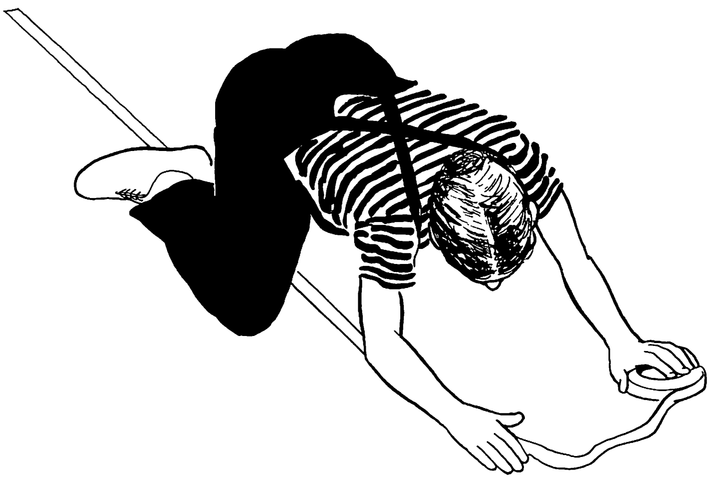
Drawing with Chalk

Grasp the chalk in your normal writing hand. Get down on the floor in a crawling position with your Turtle Clock close by for easy reference. The chalk will stay on the rug at all times. To go forward, move your opposite hand and knee forward one crawling step. Then, dragging the chalk forward with you, move your chalk hand until it's even with your other hand.

To make the turns, rotate your body with the chalk as your center or pivot point. Your turn will be just like the turns you gave the turtle on the Turtle Clock. For example, if you turn RIGHT 120, you will go from 12:00 to heading toward 4:00. Remember to reset the Turtle Clock to 0° before you make your next turn.

Drawing with Tape

If your floors are made of tile, wood, or linoleum, you can use masking tape to draw your lines. Use the same crawling position described above. One hand will pull the



tape forward as you move; the drawing hand this time will smooth the tape down to make it stick. Hold the tape down with one hand when you make your turns. You may want to break it off before starting the next move forward or back.

ACTIVITIES

With a partner, act out ''turtle'' and ''commander'' again on the floor, this time with chalk or masking tape. Use the Turtle Clock to help you decide the amount of each turn. Remember that you rotate without drawing with the chalk or masking tape. Check your 90° turns against something like the corner of this book. You can also check to see that a 60° turn is less than 90°, or a 120° turn is greater than 90°.

🔑 **18.** Take turns giving commands like these. Then make up your own. FD stands for FORWARD; BK stands for BACK.

```
a. FD 3     b. RT 60    c. BK 3
   RT 90       FD 2        LT 90
   FD 5        LT 60       BK 3
               FD 2        LT 90
                           BK 2
                           FD 6
```

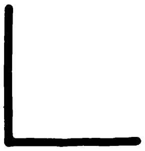
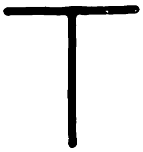
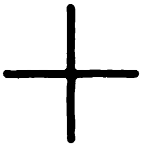
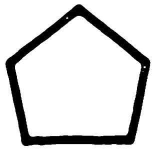
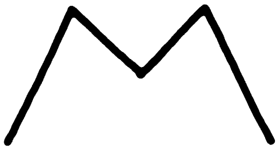
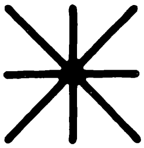
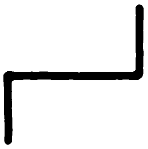
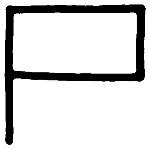
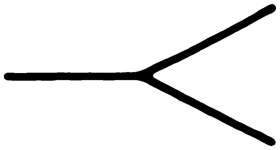
d. your own ____________

____

____

____

19. Instruct your partner to make some of these shapes and some that you design.

Chapter Two

Turtle Drawing on Paper

The Turtle Pen

An easier, more practical way to act like a turtle is to let your hand be the turtle. Holding a pen or pencil, your hand can follow the same FD, BK, RT, and LT commands. To help with the turns, you can attach a paper turtle to the pen. Here's how:

1. Cut out the Turtle Pen shape from the back of the book.
2. Glue it on an index card or heavy paper.
3. Cut it out again.
4. Punch a hole for the pen or pencil to fit.

When you draw with the Turtle Pen, FD 1 means to go forward 1 thumb width. To turn right, or left, rotate the turtle only. Then you'll be ready to go in the direction the turtle is heading. You don't need to turn your hand or the pen. Be careful not to let the paper move. You can use the Turtle Clock to judge the number of degrees to turn.

ACTIVITIES

20. Draw your own shape, and have your partner figure out and write down the commands as you move. Sketch your shape here.

Commands Shape

____

____

____

____

21. Trade the commands you just invented with another group. Did they draw the same shape you did?

Other Group's Commands Shape

____

____

____

____

____

22. What happens if the turtle is told to go past the edge of the paper? ____________

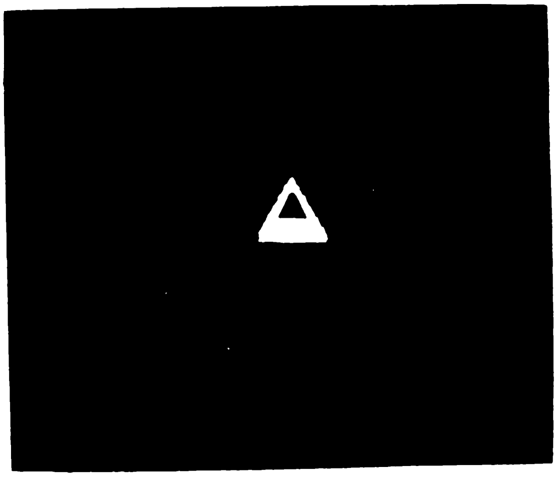
____

The Screen Turtle

The Logo turtle on the computer acts like a robot but looks like a small triangle.

Its head is the point of the triangle; its tail is the thick white bar. The turtle "holds" the pen at its center and when it draws, the line seems to come out of its middle.

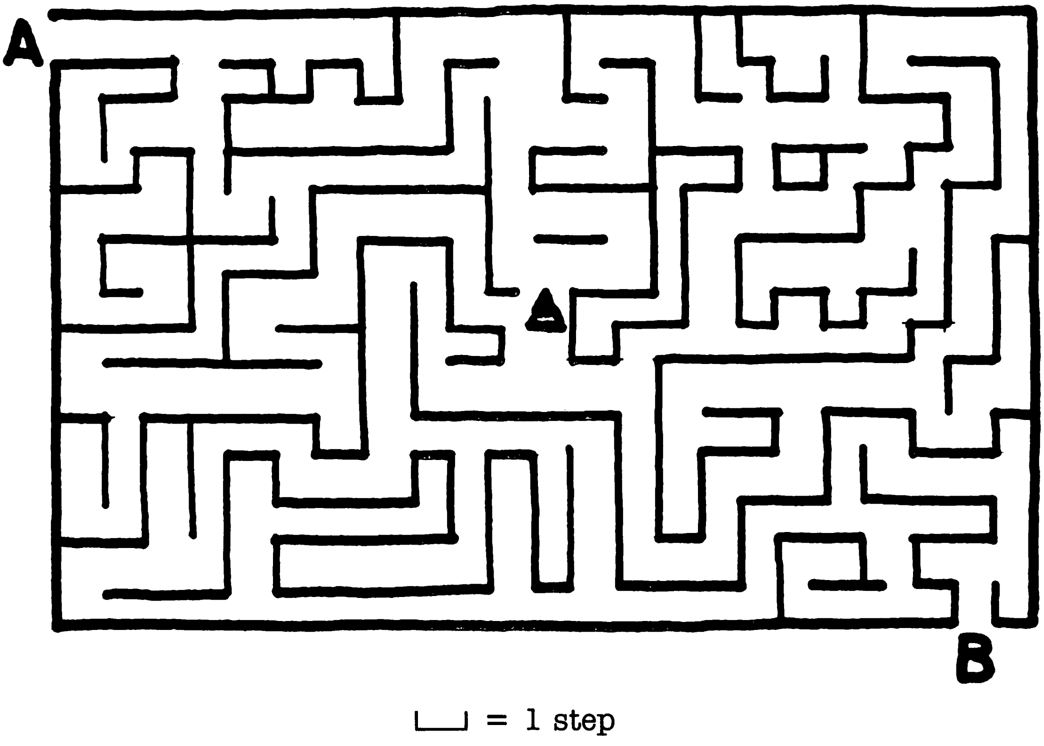
All of the commands you have just been practicing—FD, BK, RT, and LT—work with this little turtle. Remember, the turtle moves forward towards its head and backward toward its tail. Also remember, it rotates to *its* right and *its* left.



ACTIVITIES

23. Each partner picks the letter name of one of the exits on the maze below. One person gives turtle commands to his or her partner to get the turtle to the exit. Draw the path through the maze with your Turtle Pen. Then switch roles.

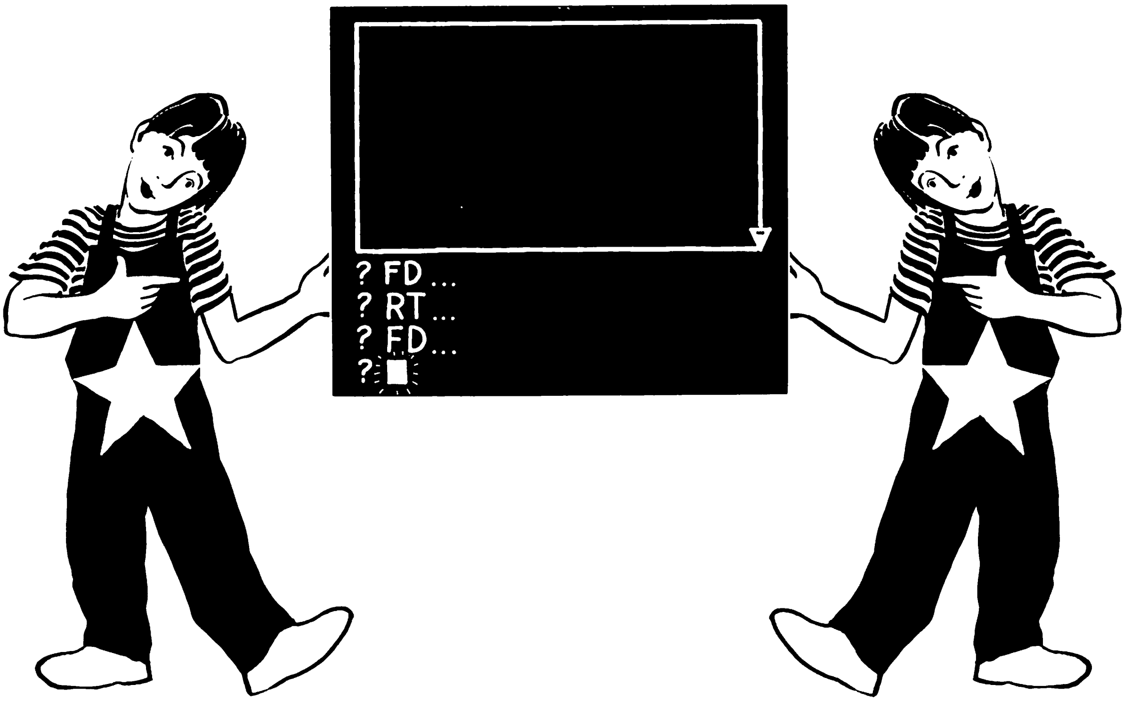
Important: Save your Turtle Pen. You will continue to use it when you write and check procedures for the computer.



CHAPTER

THREE

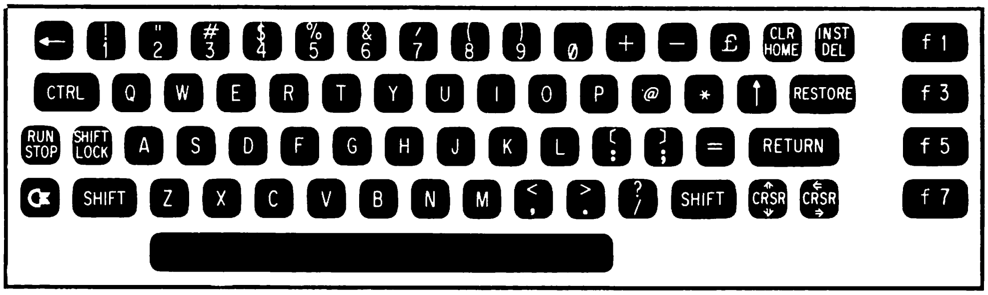
Commanding the Turtle



Chapter Three

The Commodore 64 Keyboard

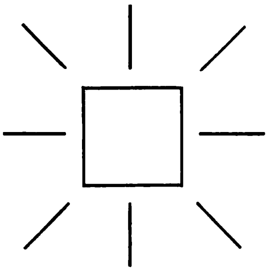
You're ready now to go to work at the computer. To give commands to the screen turtle, you must type them at the keyboard. The Commodore 64 keyboard has a few special keys that you should know about before you begin to type. (See picture of keyboard.)



← ! 1 " 2 # 3 $ 4 % 5 & 6 ' 7 (8) 9 0 + − £ CLR HOME INST DEL f 1
CTRL Q W E R T Y U I O P @ * ↑ RESTORE f 3
RUN STOP SHIFT LOCK A S D F G H J K L [:] ; = RETURN f 5
SHIFT Z X C V B N M < , > . ? / SHIFT CRSR CRSR f 7

Commodore 64 keyboard

1. When you type at the computer, you will see a flashing square called the *cursor.* It shows you where the next letter or number you type will appear on the screen. The long bar at the bottom of the keyboard is called the *space bar.* When you press it, the cursor moves forward and leaves a space.



2. The <RETURN> key moves the cursor to the beginning of the next line. It also sends to the CPU the command you have just typed. The computer doesn't know what you have typed until you press the <RETURN> key.

Example: To get the turtle to go forward 20 steps, you must type

FORWARD 20 <RETURN>

Remember, the turtle won't do anything until you press the <RETURN> key.

Important: <RETURN> means press the <RETURN> key. It doesn't mean type the letters R-E-T-U-R-N. Throughout the book, we will use pointed brackets <>

around the names of special keyboard keys to show that you press a key rather than type its letters.

3. <SHIFT>. There are two <SHIFT> keys, one on each side of the keyboard. When you *hold down* the <SHIFT> key and press another key, you get the character shown on the upper half of the key.

Examples:

a. When you type
<SHIFT> 5
you get
%

b. When you type
<SHIFT>/
you get
?

4. ←

The single arrow key on the upper left of the keyboard moves the cursor one space to the left. Letters are not affected as the cursor moves over them.

5. $\overset{\Leftarrow}{\underset{\Rightarrow}{\text{CRSR}}}$

The double arrow key on the lower right of the keyboard moves the cursor either to the right or left:

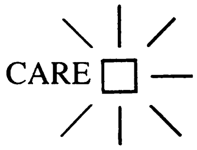
— to the right when used *without* the <SHIFT> key (because it's the character on the bottom half of the key).

— to the left when used *with* the <SHIFT> key.

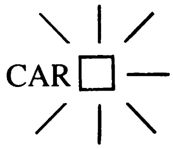
Letters are not affected as the cursor moves over them.

6. DEL stands for Delete. The <INST/DEL> key, used *without* the <SHIFT> key, erases the letter to the left of the cursor and moves the cursor one space to the left.

Example: If you type



and then press the <DEL> key, you will have



7. <CTRL> stands for control. The <CTRL> key is used for special Logo commands. You hold it down when you press certain other keys, just as you use the <SHIFT> key. Be sure to keep the <CTRL> key down until you finish pressing the other key.

Example: When you type <CTRL> G, you tell the computer to ignore everything you just typed on that line.

8. 0 (zero) and O (capital O)

Make sure you type the number 0 (at the top of the keyboard) for zero, not a capital letter O.

9. The four keys on the right side of the keyboard are called function keys. You will learn about their use in Logo later in this chapter.

ACTIVITIES

Do these exercises if you need further practice with the Commodore 64 keyboard. You can do them with or without the computer. If you do them at the computer, you must first load in Logo. (See instructions at the beginning of the next section.) If you are already familiar with the keyboard, you can go on to the next section.

1. What two keys do you have to press to type $?
2. Where is the space bar?
3. If you were to press these series of keys, what would happen?
  a. <SHIFT> 4
  b. <SHIFT> :
  c. ← ←
4. With a partner and a diagram of the keyboard for each of you, take turns calling out characters and seeing who can find the character first. Use the following:

extra-terrestrial
{your name}
{your address}
{your phone number}
OK!**!#*!

Chapter Three

Typing at the Computer

Do NOT put a disk in the disk drive before everything is turned on or your disk might be damaged.

To start up Logo you need to follow this sequence *carefully:*

1. Turn on the disk drive (the switch is at the back of drive) and the monitor or TV screen.

2. Turn on the Commodore; the red light on the drive will go on and you will hear a brief whirring noise. The word READY will appear on your screen.

3. Place the Logo Language Disk into the drive and close the door.

4. Type

```
LOAD "LOGO",8 and press <RETURN>;
```

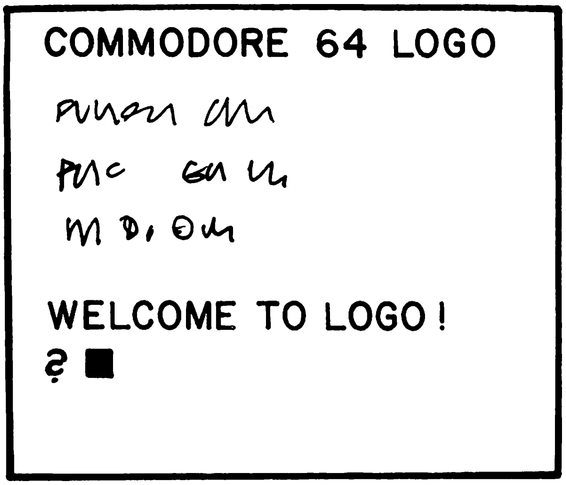
after a few seconds, the computer should respond:

```
SEARCHING FOR LOGO
LOADING
READY
```

Type

```
RUN <RETURN>
```

The drive light will go on and the whirring sound will continue for nearly two minutes while Logo is loading. Then you will see this display on your screen.



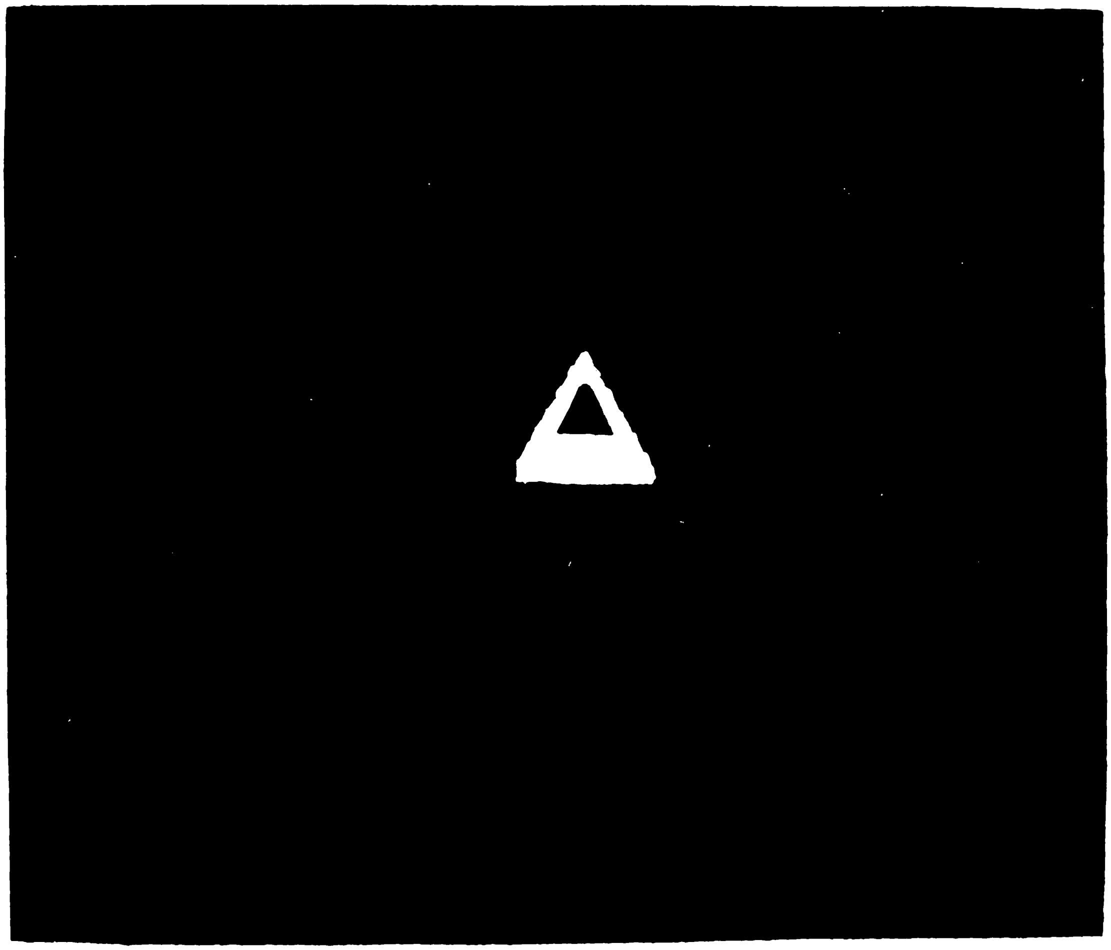
```
COMMODORE 64 LOGO

WELCOME TO LOGO!
? ■
```

The ? is called a *prompt.* It tells you that the computer is ready for you to type in a Logo command. The cursor usually flashes next to the ? prompt.

Type:

DRAW <RETURN>

You have just typed in your first Logo command! DRAW told the computer to get the turtle ready for action. The screen is now clear, and the turtle is in the center of the screen facing straight up.



The screen turtle will respond to the same commands you have been using when you played turtle and drew with your Turtle Pen. One difference is that now the turtle and the screen are tilted so that the turtle will move up and down. It is no longer walking on a horizontal surface such as your desk or the floor. Another difference is that the screen turtle is quicker and much more accurate. It will be a lot easier to get this turtle to do what you want.

DRAW

The DRAW command accomplishes three things:

1. lets you see the turtle and graphics screen;
2. puts the turtle in the center of the screen, facing up or toward 0°;
3. clears the screen of all previous drawings.

FORWARD AND BACK

FORWARD {a number}
FD {a number}   This command makes the turtle go forward the given number of turtle steps.

Examples:

```
FORWARD 10
FD 100
FORWARD 2 + 3
FD 10 / 2
```

BACK {a number}
BK {a number}   This command makes the turtle move backward the given number of turtle steps.

Examples:

```
BACK 5
BK 50
BACK 30 - 15
BK 4 * 6
```

RIGHT AND LEFT

RIGHT {a number}
RT {a number} This command changes the direction in which the turtle is heading. The turtle rotates; it does not move forward or back. The turtle rotates to its right the number of degrees given.

Examples:

```
RIGHT 30
RT 90
RIGHT 390
RT 30 * 3
```

LEFT {a number}
LT {a number} This command makes the turtle rotate to its left the number of degrees given.

Examples:

```
LEFT 45
LT 60 - 22
LEFT 360 / 4
```

Start typing in some turtle commands. Remember, you can use abbreviations: FD for FORWARD, BK for BACK, RT for RIGHT, and LT for LEFT. Make sure you type a space by hitting the space bar after the command name. A Logo command must be followed by a space because the space means the end of a command. If you type

```
BK15 <RETURN>
```

you will get a Logo message. Because you left out a space after BK, the computer thinks BK15 was the command you were giving. The computer is letting you know that it does not know that command.

You will receive other Logo messages, too. They give you important information and can help you fix mistakes. In Appendix C is a log for you to record the Logo messages you get.

Correcting Mistakes

If you hit the wrong key as you are typing, you can use the <DEL> key to erase it. If you leave out a letter, you can use the ← key to go back to the place where it should have been. Then, when you type the missed letter, it will be inserted to the left of the cursor. Use the $\underset{\Longrightarrow}{\text{CRSR}}$ key to move the cursor back to where you want to start typing again.

Once you press the <RETURN> key, you can't go back with either the ← key or the $\overset{\Longleftarrow}{\text{CRSR}}$ key to correct a mistake. You will have to retype the whole line. So, it is a good idea to type only one command on a line before pressing the <RETURN> key. That way you won't waste time retyping lines.

EDITING KEYS

← This key moves the cursor one space to the left. It does not change the character it goes over.

$\overset{\Longleftarrow}{\underset{\Longrightarrow}{\text{CRSR}}}$ This key moves the cursor one space to the right or left depending on whether or not the <SHIFT> key is used:

— to *right without* <SHIFT>
— to *left with* <SHIFT>

It does not change the character it goes over.

<DEL> Erases the character to the left of the cursor.

Notes: The $\overset{\Longleftarrow}{\underset{\Longrightarrow}{\text{CRSR}}}$ and <DEL> keys repeat automatically if held down; the ← key does not.

The cursor will automatically move down to the next line after it reaches the end of a line. If you are using either of the left arrow keys, the cursor will automatically move up to the next line.

To open a new line, put the cursor at the end of a line and press <RETURN>.

Chapter Three

ACTIVITIES

These exercises give you practice typing at the keyboard and correcting your mistakes.

5. Type
FOWRARD 30
and then correct the spelling.

6. Type
LT60
and use ← or <SHIFT> $\overset{\Leftarrow}{\text{CRSR}}$ to go back and insert a space.

7. Type in any two commands and then DRAW. What happened? When would the DRAW command be useful? ____________________

____

8. a. What happens when you type
BK   20 <RETURN>?

____

b. BK <RETURN>?

____

What do you think the message means?

____

____

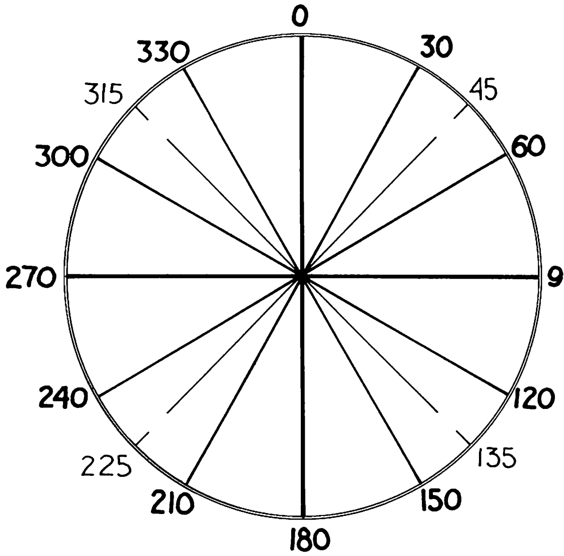
9. Type in these words and change them as shown:
a. Change POT to PLOT.
b. Change TRANSPORT to SPORT.
c. Change DIARY to DEARY.
d. Change BOZO to LOGO.

(The turtle doesn't know what any of these words means, so don't be surprised if you get Logo messages.)

Chapter Three

Moving the Turtle around the Screen

You're ready to drive the turtle around the screen and to explore the turtle's neighborhood. As you do the following activities, try to get a feel for the size of the turtle's steps and the size of the screen.



You can use the Degree Finder above to help with RT and LT commands on the screen. Trace the picture onto thin paper. Hold the Degree Finder up to the screen with the turtle at the center of the circle, facing 0°. Then you can judge how large a turn you want.

Keep moving the turtle around the screen until you feel comfortable as the turtle's commander. You should feel confident that you can get the turtle to do whatever you want.

Chapter Three

ACTIVITIES

Use the DRAW command between activities to clear the screen and put the turtle in the center facing up. Do the activities with a partner. One person can jot down commands while the other types them.

10. Give the turtle six commands. Sketch the results here:

Commands Results

____

____

____

____

____

____

11. Predict what you will get if you give the turtle these commands. Sketch your prediction and the results. Don't bother to make your sketch accurate.

Commands	Prediction	Actual Results
RT 60 FD 30 LT 90 FD 30 RT 90 FD 30		

12. Try typing each one of these commands:

a. RT 1
   RT 10
   RT 100
   RT 1000

b. FD 1
   FD 10
   FD 100
   FD 1000

Experiment some more with big steps, such as FD 341 or BK 606. What did you find out?____

____

Experiment with more big turns, such as LT 380. What did you find out? __________

____

13. Type DRAW and make the turtle go straight forward until it comes back to where it started. About how many steps did it take? ______________________________

____

Now turn RT 90 and then go forward until you are back again. About how many steps did it take this time?____

____

14. You've tried making the turtle go FD 1000 (in #12). Now try RT 45 and then FD 1000. What happens?____

____

Try these pairs of commands. (Type DRAW before you do each pair.)

a. RT 60 FD 8000	b. LT 75 FD 3000	c. You make up some.

What happened?____

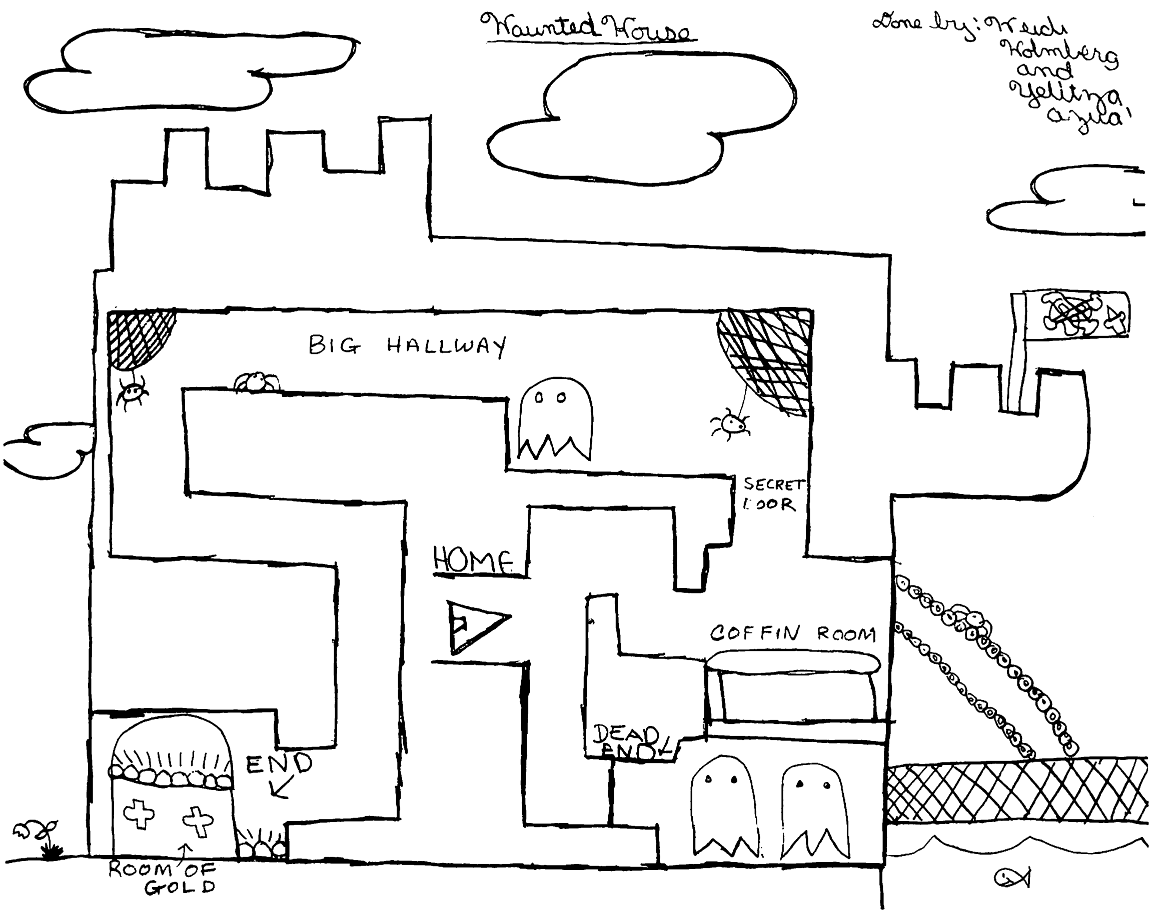
____

____

15. Work with a partner. One person holds a scrap of paper (about an inch square) anywhere on the screen. Be careful not to get fingerprints on the screen. The other person types in commands to get the turtle to hide under the paper. How many moves did it take?____

Now type the DRAW command. Can you get the turtle under the paper with just two commands? Switch places with your partner. Type DRAW. Move the paper to a new place on the screen and try to hide the turtle again.

16. Make up an adventure for the turtle. Draw a maze or adventure trail the turtle can follow. Use pencil on thin 8½ by 11-inch paper or clear plastic. Then you can tape your maze to the screen and direct the turtle out of the maze or along the trail. Here's an example by Heidi and Yelitza:



Chapter Three

More Commands

In this section you will learn more of the Logo vocabulary. For each new command, we've included a short set of exercises for you to get used to the command and to explore the new possibilities it opens up.

PENUP and PENDOWN

These two commands are for lifting or putting down the turtle's pen. After the PENDOWN command (PD for short), the turtle will draw as you move it. After the PENUP command (PU for short), the turtle will move but not draw.

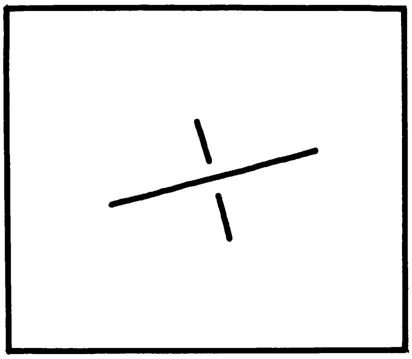
Note: When you first load in Logo, the turtle's pen is automatically down.

ACTIVITIES

17. Make the turtle draw a dotted line.
18. What do you think these commands will produce? Sketch your prediction and the results.

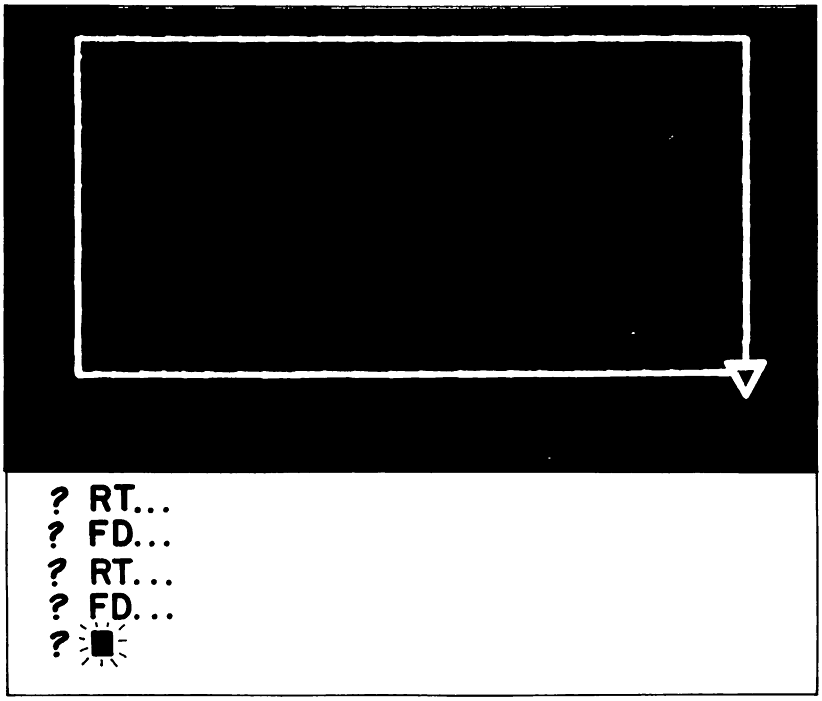
Commands	Prediction	Actual Results
FD 30		
PU		
FD 30		
PD		
FD 30		
BK 30		
PU		
BK 15		
RT 90		
FD 15		
PD		
FD 30		
BK 30		
PU		
BK 30		
PD		
BK 30		

19. Draw a line and then have the turtle jump over it.



Challenger

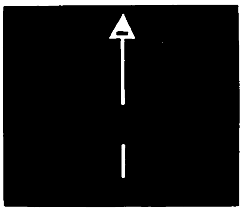
20. Make an outline frame of the screen. Show the number of steps needed to get to each edge. Hint: Make the turtle take small steps when it gets near the top of the screen. What are the dimensions of the screen?



```
? RT...
? FD...
? RT...
? FD...
?
```

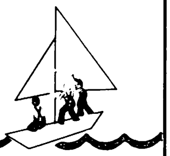
PENUP AND PENDOWN

PENUP	PU This command lifts the turtle's pen. After a PENUP command, the turtle will not draw as it moves forward or back. The pen will stay up until a PENDOWN command is given.
PENDOWN	PD This command puts the turtle's pen down. After a PENDOWN command, the turtle will draw as it moves forward or back. The turtle's pen stays down until a PENUP command is given.

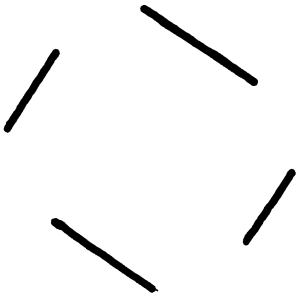


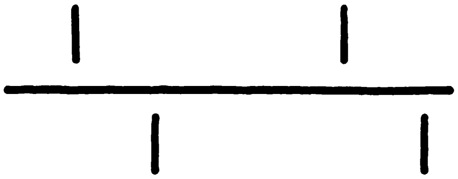
Example:

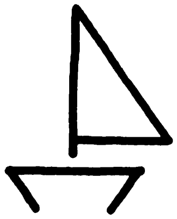
```
FORWARD 10
PENUP
FORWARD 10
PENDOWN
FORWARD 20
```

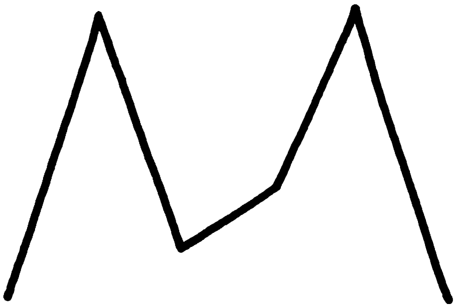


Have fun making and exploring shapes like these:









Colors

If you have a color monitor, you will want to use the sixteen colors available for drawing and for background. The Logo command for setting the turtle's pen color is PENCOLOR, abbreviated PC. PC is followed by a number from 0 to 15; each number specifies a certain color.

PC 0	black	PC 6	blue	PC 11	gray 1
PC 1	white	PC 7	yellow	PC 12	gray 2
PC 2	red	PC 8	orange	PC 13	light green
PC 3	cyan (aqua)	PC 9	brown	PC 14	light blue
PC 4	purple	PC 10	light red	PC 15	gray 3
PC 5	green				

The background can also be set to these sixteen colors. The Logo command is BG followed by one of the numbers from 0 to 15. Strange things may happen when you change pen and background colors. Some pen colors don't show up well on certain background colors. You may discover that lines drawn in certain directions (especially horizontally) show their colors better than in other directions. Changing the background *after* a picture is drawn may change some of the lines in peculiar ways! You can have some fun testing out different combinations in some of the following activities

When you first load in Logo, the background is automatically set to black (BG 0) and the pen color is automatically set to white (PC 1). If you reset the colors by giving a BG or PC command, the colors will stay as you set them until you give a new color command.

ACTIVITIES

21. Experiment with changing the pen color and background color. For example, you might type

a.

```
PC 3
FD 10
PC 4
RT 30
FD 30
PC 5
LT 60
FD 40
PC 2
```

b.

```
FD 20
RT 90
FD 20
BG 3
FD 20
RT 90
```

c. (your own)

22. What happens when the pen color and background color are the same:

____

____

____

23. Draw some long lines made up of short segments, each of a different color. For example, PC 2 FD 10 PC 8 FD 10, etc. Try lines going in different directions (horizontal, vertical, diagonal). How do your lines look when you change the background color? ______________________________

____

SINGLECOLOR and DOUBLECOLOR

When you begin to draw in color, you are in SINGLECOLOR. The lines are thin, and sometimes, if drawn close together, line colors may bleed into each other. If you type DOUBLECOLOR, the lines will be thicker and richer in color. Lines of different colors may be drawn close together without affecting each other. On the other hand, DOUBLECOLOR drawings will look less precise because of the thicker lines. You will want to experiment with these two modes to see which suits you best in your drawings.

When you switch from one mode to the other, the graphics screen is cleared. Also, the pencolor is reset to white and the background color to black, just as when you first start up Logo. As a result, you cannot draw in both SINGLECOLOR and DOUBLECOLOR in the same picture.

ACTIVITIES

24. Use the following commands to draw two lines of different colors close together. Do it first in SINGLECOLOR (which Logo does automatically if not told to do otherwise). Then type DOUBLECOLOR and type in the same commands as before. Do you see a difference?

Type:

```
PC 4
FD 100
RT 90
FD 2
RT 90
PC 7
FD 100
```

Go back to SINGLECOLOR and experiment with the FD 2 command. This is the distance that separates the two lines. How far apart must SINGLECOLOR lines be for each to keep its own color? ____

25. Now compare the two modes for drawing a triangle.

Type:

```
PC 8
RT 45
FD 100
RT 90
FD 100
RT 135
FD 140
```

Remember the thickness and intensity of color in the lines of your first triangle. Then draw it in the other mode. Be sure to type in a pencolor again or you will have a white triangle. Do you see a difference?

COLORS

PENCOLOR {a number} PC {a number}

This command sets the turtle's pen to the color indicated by the given number as shown here:

PC 0	black	PC 6	blue	PC 11	gray 1
PC 1	white	PC 7	yellow	PC 12	gray 2
PC 2	red	PC 8	orange	PC 13	light green
PC 3	cyan (aqua)	PC 9	brown	PC 14	light blue
PC 4	purple	PC 10	light red	PC 15	gray 3
PC 5	green				

The pen color stays as set until a new PC command is given. When Logo is first loaded in, the pen color is automatically set to white (1).

BACKGROUND {a number} BG {a number}

This command sets the background to the color given. The color numbers are the same as for PC. The background stays as set until a new BG command is given. When Logo is first loaded in, the background is black (0).

BG 0	black	BG 6	blue	BG 11	gray 1
BG 1	white	BG 7	yellow	BG 12	gray 2
BG 2	red	BG 8	orange	BG 13	light green
BG 3	cyan (aqua)	BG 9	brown	BG 14	light blue
BG 4	purple	BG 10	light red	BG 15	gray 3
BG 5	green				

SINGLECOLOR AND DOUBLECOLOR

SINGLECOLOR (no abbreviation)

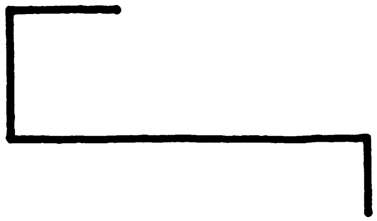
This command lets you draw with thin lines. If the lines are drawn close together, colors may bleed into each other. Unless told otherwise, the turtle draws in SINGLECOLOR.

DOUBLECOLOR (no abbreviation)

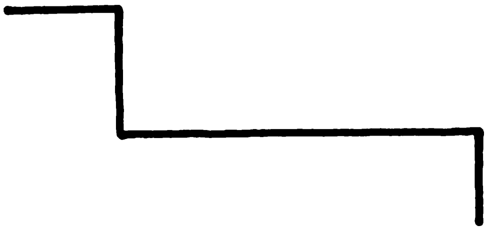
This command lets you draw with thicker lines. If the lines are drawn close together, they are less likely to affect each other.

PENERASE

Sometimes as you are typing in commands, you will make a mistake and want to erase what the turtle just drew. For example, you gave commands to make the turtle draw this:



and meant to get this:



You don't want to have to start all over again. What can you do? The solution is to put an eraser on the turtle's pen by typing

PENERASE (There is no abbreviation for this command)

Next, you have to get the turtle to walk back over the last line. You would type

BK {whatever number you just gave} if the last command was FD or FD {the number} if the last command was BK.

The eraser will stay on the turtle's pen until PENCOLOR is set back to whatever color you had been using before the mistake. So, after the unwanted line is gone, to continue drawing in white (PC 1) for example, you would type PC 1 and the correct command.

Try this example:

```
FD 50
RT 57
FD 30
PENERASE
BK 30
LT 57
PC 1
RT 90
FD 30
```

ACTIVITIES

26. Figure out what commands were given to draw the example on page 50. Type your commands in and then erase the last line.

Commands to Draw	Commands to Erase
________________	________________
________________	________________
________________	________________
________________	
________________	
________________	
________________	
________________	

27. Type in some commands of your own and then erase the last line.

28. Make up some commands of your own. Then erase more than one line or even everything you drew.

PENERASE

PENERASE (no abbreviation)

This command erases a line when the turtle walks back over it. If the turtle has gone

FD 100

and you type

PENERASE
BK 100

the line will be erased and the turtle will be back at its prior location. Be sure to type in a PENCOLOR command so the turtle can continue drawing.

Example:

FD 20

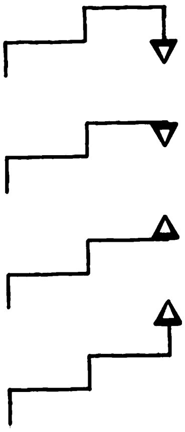
PENERASE

BK 20

PC 1

RT 180

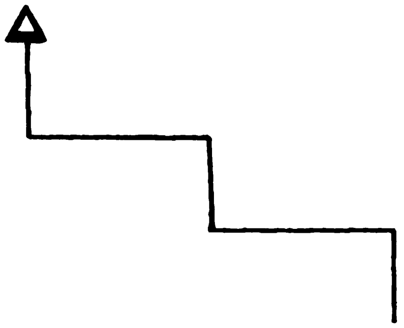
FD 20



HIDETURTLE and SHOWTURTLE

Suppose you were drawing a staircase, and you typed in these commands:

```
FD 15
LT 90
FD 45
RT 90
FD 15
LT 90
FD 45
RT 90
FD 15
```



As you look at the stairs, you think the last one looks too tall. What's wrong? The turtle makes the top stair look different from the others. It would be better to see the effect without the turtle.

Much as you may like the turtle, there will be times when you'd rather not have it in sight. Use the HIDETURTLE command, abbreviated HT, to make the turtle disappear. You won't need to worry, however. It is simple to get the turtle back to the same place again by just typing ST for SHOWTURTLE.

ACTIVITIES

29. Type in some commands and then hide the turtle. Can you tell where it is?

____

30. Hide the turtle first, and then give the turtle some commands. Try this with the PENUP. After a while, guess where the turtle is. Were you right? To prove it, show the turtle.

31. Which do you like better, giving commands with the turtle in view or hidden?

____

Can you think of times when you would want to see the turtle and times when you wouldn't?

____

HIDETURTLE AND SHOWTURTLE

HIDETURTLE	HT This command hides the turtle from view. The HT command does not make the turtle move. If the turtle is hidden and you give FORWARD, BACK, LEFT, or RIGHT commands, the turtle will move even though you can't see it move.
SHOWTURTLE	ST This command brings the turtle into view. The turtle will reappear at whatever place your commands left it. When Logo is first loaded in, the turtle will be seen as it draws.

Note:
The turtle draws faster when it is hidden than when it is shown.

SPLITSCREEN, FULLSCREEN, and TEXTSCREEN

Type in these commands:

```
BK 110
LT  90
FD  20
RT  45
FD  10
RT  45
FD  10
```

Where did the turtle go? Did it wrap around to the top of the screen? Type

```
ST            (SHOWTURTLE)
```

Does that make the turtle appear?

The turtle has gone to the bottom part of the screen, where you see the commands you have typed. You can see the turtle if you type

<f5>

(This is one of the four "function keys" on the right side of your keyboard.) Now you have the full screen for turtle drawing.

If you want to see your commands again, you simply press

<f3>

This gives you the split screen, which splits the screen between space for turtle drawing and space on the bottom for seeing commands. You can go back and forth any time you like between a full screen for turtle drawing and a split screen by typing

<f5>   or   <f3>

You may also have noticed that some of your commands disappear underneath the upper part of the screen as you type in new commands. If you want to see all your commands and no turtle drawing, you can press

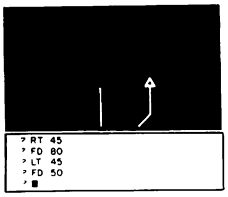
<f1>

In TEXTSCREEN the entire screen is used to show typed commands. You can go back and forth among TEXTSCREEN, FULLSCREEN, and SPLITSCREEN by pressing

<f1>   or   <f5>   or   <f3>

SCREEN DISPLAY

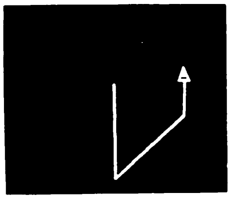
SPLITSCREEN <f3>



```
? RT 45
? FD 80
? LT 45
? FD 50
? ■
```

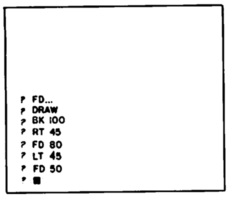
This command divides the screen into two parts. The top part is for turtle drawings, and the bottom part is for seeing commands. When you first start drawing (after the DRAW command), the screen will be split. The turtle will use the whole screen for drawing, but you won't be able to see the lines it draws on the bottom part.

FULLSCREEN <f5>



This command makes the entire screen available for turtle drawings.

TEXTSCREEN <f1>



```
? FD...
? DRAW
? BK 100
? RT 45
? FD 80
? LT 45
? FD 50
? ■
```

This command uses the whole screen for commands, not drawings. You can use the textscreen to see a screenful of old commands. The drawings won't be erased while you are in TEXTSCREEN. You can see them again by typing <f3> or <f5>.

You can go from SPLITSCREEN to FULLSCREEN to TEXTSCREEN without changing the commands or the drawings.

ACTIVITIES

🔑 **32.** How far from the center of the screen is the split screen boundary? Use the turtle to find out. ____

🔑 **33.** Draw a border to outline the entire screen. You will have to type <f5> to see it all and <f1> to see all your commands.

34. Type in this set of commands, and sketch the results.

Commands Results

```
FULLSCREEN
PU
RT 46
FD 191
PD

FD 30
RT 90
FD 30
RT 90
FD 30
RT 90
FD 40
RT 90
FD 40
RT 90
FD 50
RT 90
FD 50
RT 90
FD 50
RT 90
FD 10
HT
```

Challenger

35. Can you make up a design in the corners of the full screen?

Your Commands Sketch

____

____

____

____

____

____

____

____

____

____

Chapter Three

Letting the Computer Calculate

The turtle expects a number after commands such as FD, BK, LT, and RT, but the number doesn't have to be a simple integer such as 10 or 95. The computer can do some arithmetic to figure out what the number of steps or degrees will be. So it is perfectly correct to type something such as

```
BK 20 + 35          or          LT 90 - 45
```

In the examples above, the computer will add or subtract. Addition is shown by + and − is shown by minus.

The multiplication and division signs are a little different on the computer from those you are used to. The asterisk (*) is used to show multiplication; the slash (/) is used to show division. Here are some examples:

```
FD 30 * 6      RT 90 / 2
```

You will probably find that putting sums in a command is particularly useful when you are not exactly sure how many degrees you want the turtle to turn. For instance, you may know you want the turn to be bigger than a right angle—perhaps a right angle and a half of another. Then all you have to do is type

```
RT 90 + 90 / 2
```

The computer will figure out for you that you wanted a 135° angle.

Using multiplication and division can be useful when you want to change the size of a turtle drawing. Multiplication can be used to enlarge a design; division can be used to make it smaller. For example, if you like a design you drew but want it to be half size, you can simply change all your FD and BK commands like this:

```
from FD 50                    to this FD 50 / 2
     LT 75                            LT 75
     BK 25                            BK 25 / 2
```

Notice that you don't change the number of degrees in the turns. Why not?

ACTIVITIES

36. Experiment by putting addition problems in the FORWARD command, such as

```
FD 30 + 5          or          FD 10 + 5 + 58
```

Do the same with RT, LT, and BK.

37. Experiment the same way with subtraction. What do you think will happen if you type

```
FD 30 - 80
```

Your Guess Result

38. Sketch the results of these commands. Type DRAW between commands

Commands Sketch Actual Result

```
FD 70 - 30
BK 70 - 30
FD 30 - 70
BK 30 - 70
```

39. Sketch the results of these pairs of commands. Type DRAW between pairs of commands.

Commands Sketch Actual Result

```
RT 60 - 30
FD 20

RT 30 - 60
FD 20

LT 60 - 30
FD 20

LT 30 - 60
FD 20
```

40. Here are commands for drawing a hat. Make the hat twice as big and then half as large (or even bigger or smaller) by using * and /.

```
RT 90
FD 60
BK 10
LT 120
FD 20
LT 60
FD 20
LT 60
FD 20
HT
```

Challengers

41. Experiment by using fractions as the number of steps or degrees, such as BK 45 / 8.

Commands Guesses Results

Any surprises?

42. Explore the use of negative numbers after the four basic commands, for example:
RT −30
BK −50
Can you state a general rule for each command?

FD {−number}

BK {−number}

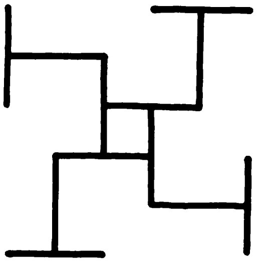
RT {−number}

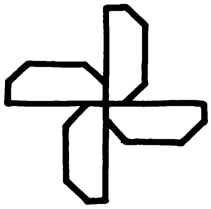
LT {−number}

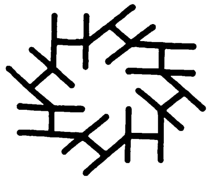
CHAPTER

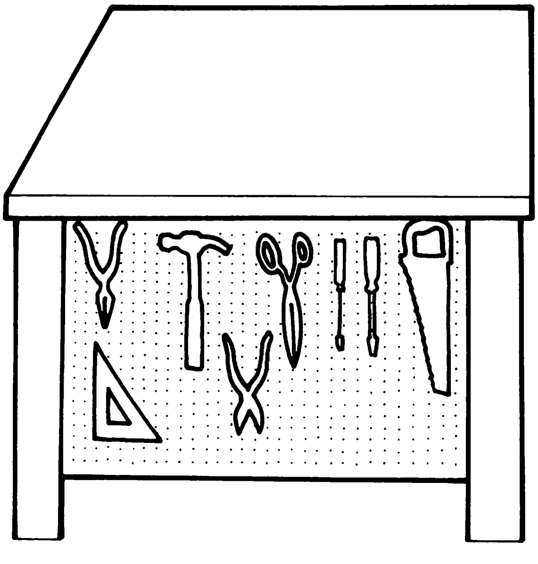
FOUR

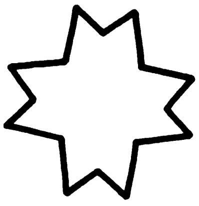
Procedures

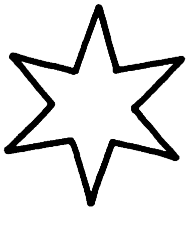












Chapter Four

Defining Procedures

You've learned enough of the basic Logo vocabulary that you can now start teaching new words to the turtle. When the turtle learns a new word or command, two important things happen:

1. The turtle will remember how to perform the new command and will do it any time you want.
2. The turtle will be able to make more complicated and interesting drawings.

Once you start teaching the turtle new words, you will be able to explore and create new designs on your own. Think of yourself as an artist-sculptor-carpenter. You have a ''workbench'' (your computer) where you do your creating. You need materials and tools to work with. The basic Logo vocabulary you have already learned is like a set of tools. The *procedures,* or new words you are about to teach the turtle, are like materials. A single procedure is like a square of cloth. It may be pretty by itself, or it may be used with other pieces of cloth to make a patchwork quilt. In the same way, sometimes a new Logo word you define will make something beautiful by itself. Other times you will use it with other words to make more involved designs.

It will be important for you to keep your "workbench" neat and organized. At the end of each computer session, you will save your work on a disk. (Directions for saving procedures are on pages 82–83.) That will be like putting boxes of materials away on a shelf by your "workbench."

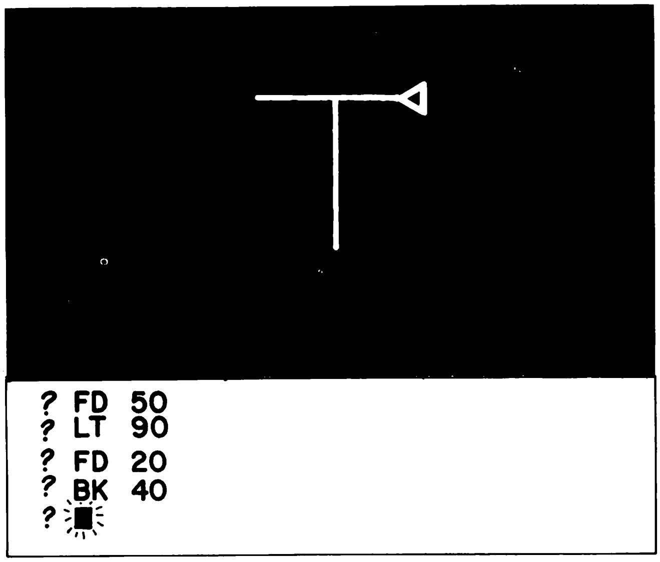
Defining Your First Procedure

A procedure is a new word or command that you will teach the turtle. You have to teach the turtle how to proceed or how to carry out your command. If you think of a procedure as a word in the turtle's growing vocabulary, you'll see that you have to define the word, or teach the turtle exactly what it means. That's why we talk about *defining procedures*.

We're going to start off by teaching the turtle how to draw some letters of the alphabet. These are easy for everyone to do, and you will be surprised a little later—as we were—by the number of interesting and even beautiful designs that can be made out of letters of the alphabet.

Let's start with the letter T. We'll use the basic commands to get the turtle to draw a T. Load Logo into the computer and type in these commands (Remember to type <RETURN> at the end of each line):

```
DRAW
FD 50
LT 90
FD 20
BK 40
```



```
? FD 50
? LT 90
? FD 20
? BK 40
?
```

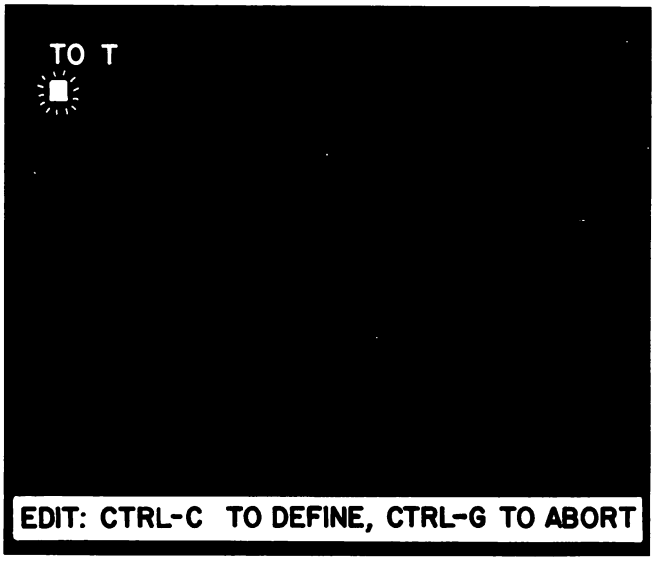
Sure enough, the turtle draws a T. (If you made a typing mistake, start over by typing DRAW again.) This is not the only way to get the turtle to draw a T and may not be the one you like best, but it's a good one to start with.

Edit Mode

Now comes a big step. We will teach this series of commands to the turtle. We will teach it how to "T". We start by typing

TO T <RETURN>

You have just entered the *Editor*. The screen looks different, and the turtle has disappeared.



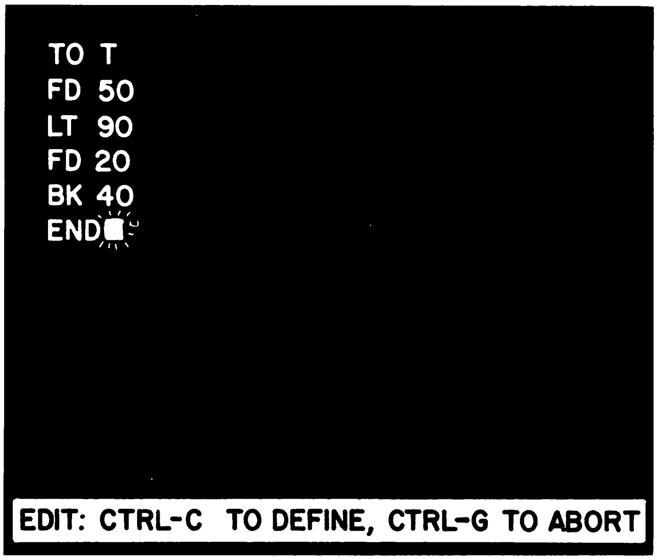
```
TO T
```

EDIT: CTRL-C TO DEFINE, CTRL-G TO ABORT

Logo has two different screens, also called two *modes*. The one you have been using so far is called *Direct Mode* because the turtle carries out your commands directly. The second mode is called *Edit Mode* or the Editor. It is a little like a special room where you go to write and change your own Logo procedures.

In the Editor, you can type in commands, but you won't see the turtle carrying them out. You can imagine that the turtle is busy learning and memorizing while you're in the Editor and can't be drawing too.

Now type in the commands for making a T, starting with FD 50. You don't need to start with DRAW. Type the commands just as you did before, one to a line, with <RETURN> at the end of each line. When you're finished, type END. END will tell the turtle that it has all the commands it needs to make a T. Your screen should look like this:



```
TO T
FD 50
LT 90
FD 20
BK 40
END

EDIT: CTRL-C  TO DEFINE, CTRL-G TO ABORT
```

That's all the turtle needs to know, so you are ready to leave the Editor. At the bottom of the screen are instructions for what to do next. Type <CTRL> C to define your new command or type <CTRL> G to abort it or just forget it. You want to define the T command, so type

<CTRL> C

(Be sure to hold down the <CTRL> key and then press C.) You will have to wait a few seconds, and then you'll see the messages,

PLEASE WAIT
T DEFINED

Now check to see if the T command works. Type

T <RETURN>

T is now a command just like LT 60. Did the turtle draw your T? If so shout ''hooray!'' and congratulate yourself.

Correcting Mistakes

If not, you probably made a typing mistake. Don't worry. You've already had practice correcting mistakes. You just have to use the same methods as you did before (see page 36), but first you must get back into the Editor.

To go back to the Editor, type

TO T <RETURN>

There is your procedure! Now use your arrow keys to get to your mistakes and the <DEL> key to erase them. If you didn't have any mistakes, just practice moving the cursor in the Editor. Watch how the cursor automatically jumps down to the next line from the end of the line above. For example, if the cursor is on the 0 in 50 and you press $\underset{\Longrightarrow}{\text{CRSR}}$ three times, the cursor will jump down to the L in LT. You can hold down the $\overset{\Longleftarrow}{\underset{\Longrightarrow}{\text{CRSR}}}$ key to make it repeat.

When you are finished, you must type <CTRL> C to leave the Editor. (You can type <CTRL> C from anywhere in the Editor; you don't have to be at the end of your procedure.)

If you have entered the Editor, made some changes, and then decide you don't like the changes after all, you can leave the Editor by typing

<CTRL> G

The turtle will remember your original commands and ignore anything you just changed.

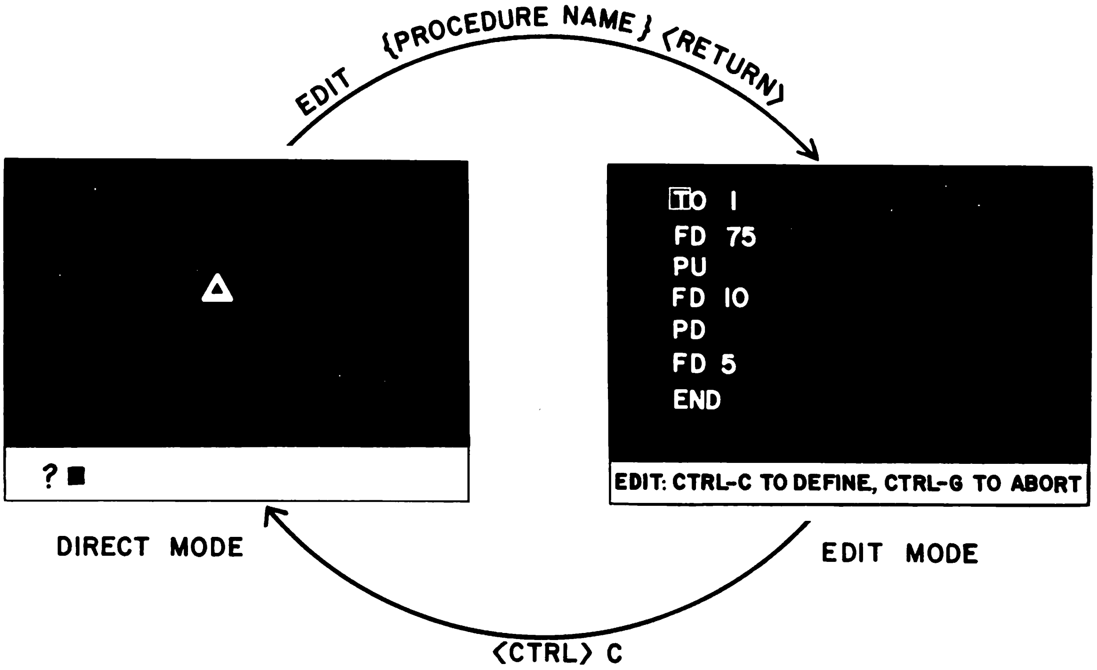
Now try typing

T <RETURN>

to check that your procedure works the way you want it to. If you still have mistakes, go back to the Editor and try again to fix them.

REFERENCE

DIRECT MODE AND EDIT MODE


EDIT {PROCEDURE NAME} <RETURN>
?■
EDIT: CTRL-C TO DEFINE, CTRL-G TO ABORT
DIRECT MODE
EDIT MODE
<CTRL> C

```
TO 1
FD 75
PU
FD 10
PD
FD 5
END
```

To go from Direct Mode to Edit Mode, type
    TO {procedure name} <RETURN>
To go from Edit Mode to Direct Mode, type
    <CTRL> C   to define the procedure
or <CTRL> G   to make the computer ignore whatever you have just typed.

POTS

You have just defined your first procedure, and you know it works. Another way to make sure the procedure is part of the turtle's vocabulary is to type the Logo command, POTS. POTS is an abbreviation for Print Out Titles. (See Command Reference.) The titles or names of all the procedures you have defined will be printed on the screen. Try it. You should see

```
TO T
```

printed on your screen. (You may have to type <f1> to get a full text screen in order to see all the titles.)

Recorder

When you're first figuring out the commands you need for your procedure, it's helpful to have a partner. While you're experimenting with the commands in Direct Mode, one person can type in the commands and the other, the recorder, can write them down on paper. Then when you go to Edit Mode to define the procedure, and the commands you just typed disappear from the screen, the recorder can read back the commands.

The recorder can also make notes about the commands. For example, if you type

```
FD 40
```

and then decide that wasn't far enough, you then type FD 20. The recorder's notes could look like this

```
FD 40}
     }    FD 60
FD 20}
```

When you define the procedure in the Editor you would only have to type FD 60.

If your computer time is really limited, you can figure out the commands you want by working on paper with a Turtle Pen. Again, it helps to have a partner who can record the commands.

Working out commands (either in Direct Mode or on paper) before you type them in Edit Mode usually ends up saving you time.

Naming Your Procedure

Give your procedure a name that describes what the procedure does. For example, procedure T will draw a T. By giving a meaningful name, you will remember what the procedure is. Sometimes a few weeks will go by before you see the procedure name again, and a name like LS or SUANO will mean nothing to you.

You will want the procedure name to be fairly short, so that you don't have to do a lot of typing. Abbreviations are fine as long as they carry meaning. For example, it's pretty obvious that SQ stands for SQUARE. On the other hand, LS, standing perhaps for LEFT SIDE, is not a good procedure name.

After you type in a procedure name and press <RETURN>, Logo reads the characters you typed in until it comes to a space. Then it knows that it has come to the end of a procedure name. For that reason, you can't have separate words in your procedure name. If you need to have two or more words, you must connect them in some way. Usually, a period between the words works best. For example, LT.SIDE would be a good name for a procedure that moves the turtle to the left side of the screen.

To sum up, you want to choose a procedure name that will be easy to remember and easy to type, and has no spaces in it.

REFERENCE

TO DEFINE A PROCEDURE

1. Think of a name for your procedure and work out the commands you want for the procedure.

2. To enter Edit Mode, type
TO {procedure name} <RETURN>

3. Type in the commands.

4. Type END

5. Type <CTRL> C
to define the procedure and to return to Direct Mode.

6. Check to see that the procedure works. Type
{procedure name} <RETURN>

7. Return to the Editor to correct mistakes if necessary. Type
TO {procedure name} <RETURN>
Use the edit keys to correct mistakes. Type <CTRL> C to redefine. Check to see if the procedure works now.

Chapter Four

ACTIVITIES

Do these activities with a partner. One person will be the recorder while the other types; then switch jobs. Follow the steps in the summary of how to define a procedure. WARNING: When you have to leave the computer, even if you are not finished with the activities, BE SURE TO SAVE YOUR WORK ON A DISK. Have your teacher help you, or follow the directions on pages 82–83. As soon as you turn off the computer, the turtle will forget the procedures you've taught it *unless* you have saved them on a disk.

1. To practice defining procedures, type in this procedure to draw an L.

```
TO L
  LT 90
  FD 30
  RT 90
  FD 50
END
```

Remember to type <CTRL> C to finish defining the procedure. Sketch the L here (but don't bother to make it exact).

🔑 **2.** Draw one or more of these right angle letters on the screen, and then define a procedure for it.

H I U

There are many ways to make a letter. For now just choose one way. Later you will explore different ways of making the same letter.

Record your procedure here: Sketch the turtle drawing for it here.

TO ______________

____

____

____

____

____

END

3. Draw one or more of these sharp-angle letters, and then define procedures for them.

K V A N M Y Z X

Procedures

Sketches

4. One of the fun things to do with letters is to repeat them. Funny things sometimes happen that you don't expect. Pick one of your letters that you wrote a procedure for, and type it several times. For example:

L L L L <RETURN>

Sketch the results here:

Challenger

5. Try to make one of these letters with curves in it:

O P R Q C B D G S J

Procedure

Sketch

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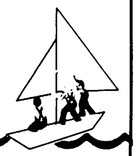
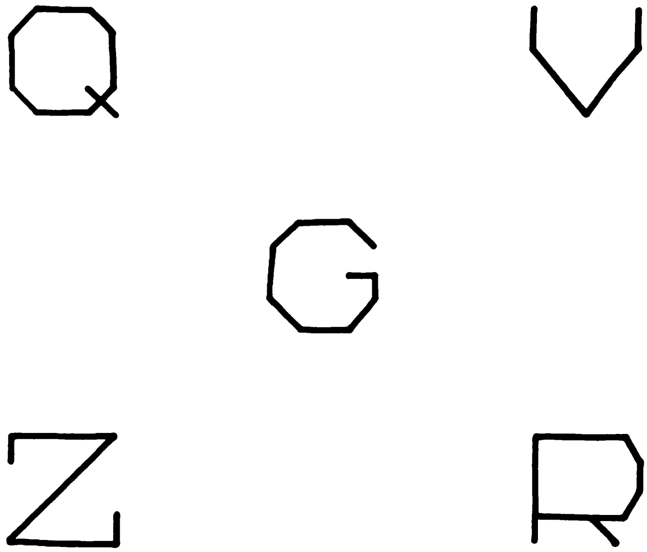
Chapter Four





Chapter Four

Changing Procedures

Logo is a more flexible language than English. Any time you want to, you can change the meaning or definition of a word you have taught the turtle. All you have to do is go into Edit Mode and make changes to the list of commands of the procedure. You've already done this to correct typing mistakes. Now you will play around with changing the series of commands you have given the turtle in the definition. For example, if you decided you wanted to make the T procedure draw a small *t* instead of a capital T, you could change the commands to make the cross of the T lower down and to put a curve on the bottom.

You can even change the name of a procedure. You should stay with the same general rules for names: the name should tell what the procedure does, and it must be only one word. All you have to do to change the name is: Enter the Editor, move the cursor to the title line, erase the old name with the <DEL> key and then type in the new name. When you type

```
<CTRL> C
```

to define the renamed procedure, you will then have *two* procedures: one with the new name and one with the old. If you decide you only want to keep one, you should erase the other one by using the ERASE command. Type

```
ERASE {procedure name}          or ER {procedure name}
```

(See Command Reference.) Next type

```
POTS
```

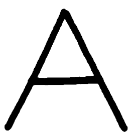
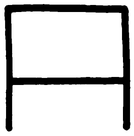
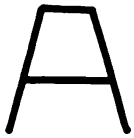
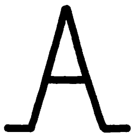
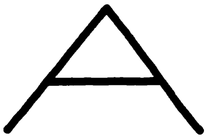
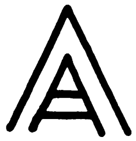
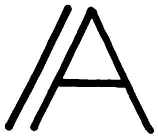
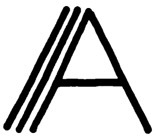
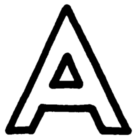
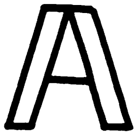
to check that you have all the procedures you want and none you don't want.

Here are some activities to get you started. Feel free to play around in any way you like with your procedures.

ACTIVITIES

6. Pick one of your letters and change it slightly by changing something in the procedure. You may want to change an angle in a letter or the size of a letter or add extra lines to a letter.

Here are some ideas:
Change H to h
Change I to i
Change

New Definition

Sketch

____

____

____

____

____

____

____

____

7. Change the name of one of the procedures you just worked on. For example, if you changed your H procedure from an H to an h, you might want to call the new procedure CHAIR (because that's what a small h looks like).

Old name ____

New name ____

8. Add a PC (pencolor) command or a BG (background color) command to one of your procedures.

9. Make one of your letters bigger or smaller.

10. Here's a procedure for F. Type it in and define it.

```
TO F
  FD 30
  RT 90
  FD 15
  BK 15
  RT 90
  FD 15
  LT 90
  FD 10
END
```

Have the turtle draw it to check if you typed it in correctly.

Now go back to the Editor. Change the title and add some commands so you make it the letter E. Remember to use <CTRL> C to define your new procedure for the letter E. Then test both the E and F procedures by having the turtle draw them.

Your E Procedure   Sketch

____

____

____

____

____

____

____

____

____

11. Choose any capital letter, change it to a small letter, and then change its name, too. You should have two procedures with two names. When you rename your procedure for a small letter, you might want to give it a name such as LITTLE.A

First Procedure

Sketch

____

____

____

____

____

____

____

____

____

____

____

Second Procedure

Sketch

____

____

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____

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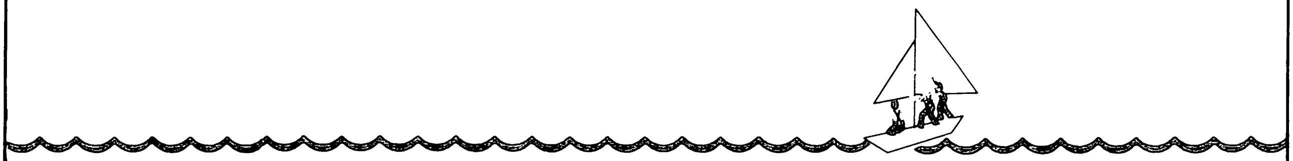
____

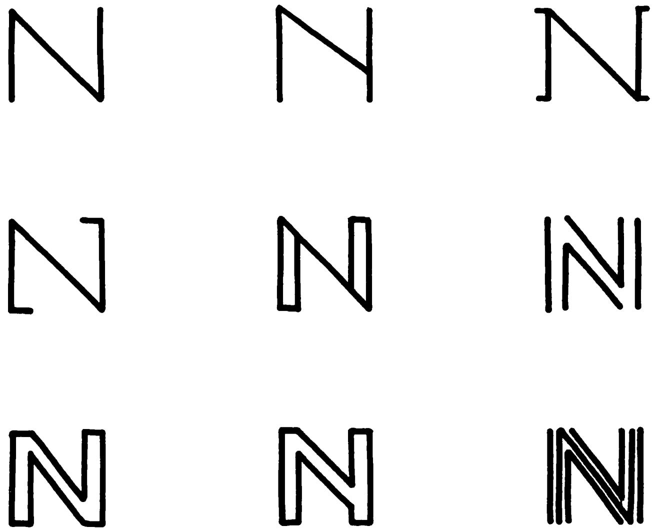
____

____

____

Chapter Four





Chapter Four

Saving Procedures

When you define procedures, they are automatically saved in the computer's temporary memory. All the information is being stored as codes of 0's and 1's in the little chips inside the computer. The trouble is that as soon as you turn the computer off, the current that made up the 1's is gone, and all the information is lost. After all your hard work, you surely don't want to lose your procedures!

To save your procedures permanently, you must store them on a disk in the disk drive. The disk is like the storage shelf of your workshop. It's easy to store your procedures; the only hard part is remembering to do it.

Take out the Logo language disk and put your own initialized disk in the disk drive. (See Appendix D for instructions on how to initialize a disk.)

When you are finished with your session at the computer, type

```
POTS <RETURN>
```

to see the names of your procedures. Make sure that all the procedures you want to save are defined and that you don't have any extra ones. If you see a procedure you don't want to save, you can erase it by typing

```
ERASE {unwanted procedure} or ER {unwanted procedure}
```

All the procedures you don't erase will be saved together in one group called a *file*. All the procedures in the temporary memory, or workspace, get saved at the same time. You don't save each one separately even though you defined them separately.

Next, type the SAVE command to store the set of procedures on the disk. You must give your file a name, just as you would want to label a box of materials in your workshop. The name should describe what is in the set of procedures and must not have a space in it. It's a good idea to add your own name, too, if your file will go on the same disk as your classmates' files.

If your name is Susan and you just finished defining some letter procedures, you could type

```
SAVE “SUSANLETTERS <RETURN>
```

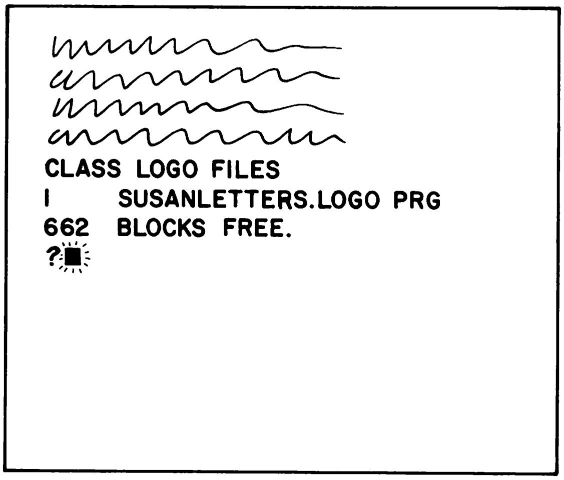
Notice that you must put a “ before the name of your file with no space between the “ and the file name. You don't put a “ at the end of the name. The first quote tells Logo that it is about to read the name of a file, and the space tells Logo that it has read the whole name. Finish typing your SAVE command now, using your name instead of SUSAN.

The disk drive will whir as your procedures are copied onto the disk.

Next, type

```
CATALOG <RETURN>
```

The name of your file should now appear on the screen in a message like this:
{name}LETTERS.LOGO PRG



```
CLASS LOGO FILES
1    SUSANLETTERS.LOGO PRG
662  BLOCKS FREE.
?■
```

Now that you know your file has been saved, you can finish your cleanup of your workbench. The procedures you saved are still in the workspace. Type
POTS <RETURN>
to see them. To clear them out so that the next person will have a clean workspace, type
GOODBYE <RETURN>
This command will erase all your work from the computer's temporary memory, but the basic tools of Logo are still there for the next person. To make doubly sure that you have cleaned up properly, type
POTS <RETURN>
All you should see is the ? prompt, which means that no procedures are in the temporary memory.

To get your procedures back again, type
READ "{name}LETTERS <RETURN>
This command is just like the SAVE command. You need to type only one ", and you don't need to type .LOGO or PRG. The disk drive will spin while your file is being copied from the disk into the workspace. The procedures are now in both places: in the workspace and in the file on the disk. (The READ command does not change the file on the disk at all.) If you type
POTS <RETURN>
you will see the list of procedures now in the workspace. You can type some of the procedure names to see that they run just as they did before. When you're all finished, type
GOODBYE <RETURN>
Now if you turn off the computer, you don't need to worry. You can always get your procedures back.

WORKSPACE COMMANDS

TO {procedure name}	Go to the Editor, or Edit Mode, to define a new procedure or to edit a procedure.
EDIT {procedure name} or ED {procedure name}	Go to the Editor to edit the procedure.
POTS	PRINT OUT TITLES Print Out Titles of all procedures in the workspace.
ERASE {procedure name} or ER {procedure name}	Erase the given procedure from the workspace.
GOODBYE	Erase all procedures in the workspace.

SAVING AND READING PROCEDURES

To save a set of procedures to the disk,

1. Type

```
POTS <RETURN>
```

to make sure you have exactly the set of procedures you want to save. Erase any procedures you don't want to save by typing ERASE {procedure name}

2. Type

```
SAVE "{file name} <RETURN>
```

3. Type

```
CATALOG <RETURN>
```

to make sure the new file is listed. (The name you just typed plus a period and the word LOGO should appear on your screen.)

4. Type

```
GOODBYE <RETURN>
```

to clear the workspace.

To load your file back in from the disk,

1. Type

```
GOODBYE <RETURN>
```

to make sure the workspace is clear.

2. Type

```
READ "{file name} <RETURN>
```

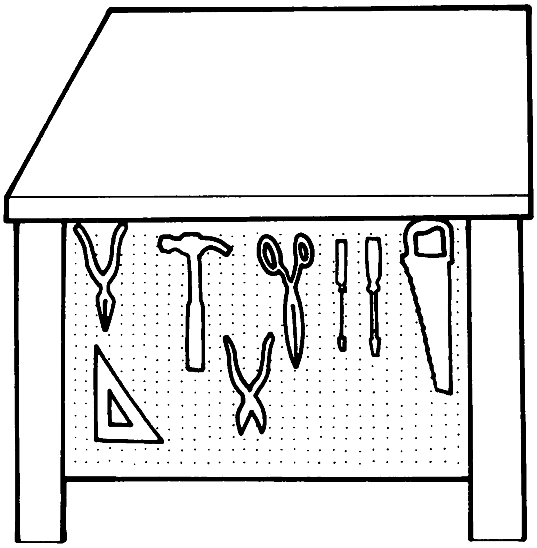
to load in your file.

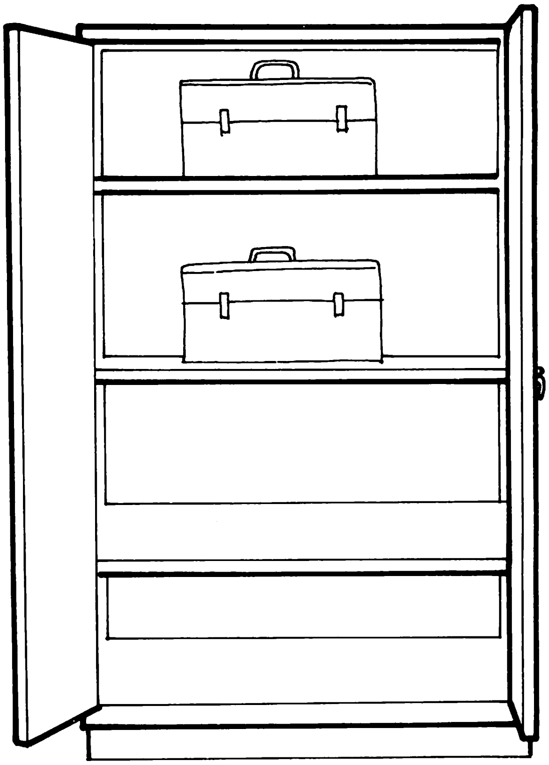
3. Type

```
POTS <RETURN>
```

to check that your procedures are now in the workspace. Then run or edit procedures as you need to.

REFERENCE





WORKSPACE

(temporary memory)

It contains procedures.

The following refer to it:

- POTS – prints out titles of procedures.
- TO {procedure name}
  <CTRL> C

  — adds procedure to workspace.
- ERASE {procedure name}

  — erases procedures.
- GOODBYE – clears workspace.
- {procedure name} – runs the procedure.

DISK

(storage)

It contains files.

The following commands refer to it:

- CATALOG – prints out names of files.
- SAVE "{file name}

  — adds file to disk.
- ERASEFILE "{file name}

  — erases file.
- READ "{file name} – reads file into workspace.

MANAGING FILES

CATALOG Shows a list of all the files on the disk.

SAVE "{file name}

Saves all the procedures in the workspace at once in a file on the disk. The file will have the given name followed by .LOGO

Notes: You should type only a first ".

After you save a file, its procedures still remain in the workspace. If you want to clear the workspace, type GOODBYE.

If you give your file the same name as an existing file, the old file with that name will be *erased* and replaced with the new file.

READ "{file name}

Loads the file with the given name from the disk into the workspace.

Notes: Do not type .LOGO at the end of the file name.

Whatever procedures were in the workspace before you typed READ will still be there. If you want just the procedures in the given file, you must clear the workspace before you type READ.

The READ command does not affect the contents of the file on the disk. The file stays on the disk as it was.

ERASEFILE "{file name}

Erases the file with the given name from the disk. Does not affect procedures in the workspace.

Chapter Four

Building on Procedures

Repeating a Procedure

Now that you have defined some procedures, you are going to start to see the power of the computer. You have taught the turtle a new command by defining a procedure. The turtle is ready to obey, or perform, the command any time you want. All you have to do is type the name of the procedure. Unlike a person, the turtle doesn't care how many times you give it the command. The turtle won't complain, get tired, talk back, or rebel.

To see how this works, turn on the computer and load in Logo. Put in your own disk and type

```
READ "{name} LETTERS
```

to load in the procedures you defined before. Type

```
POTS
```

to check that all the procedures were loaded in. Next type

```
T <RETURN>
```

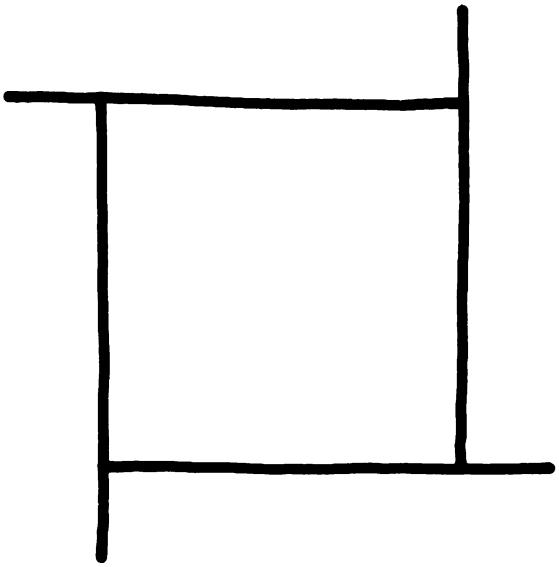
The turtle should draw the T as you taught it before. Now type

```
T <RETURN>
```

again. What happens? Type

```
T T T T <RETURN>
```

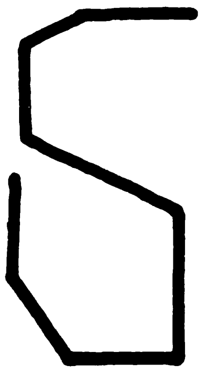
Be sure to leave at least one space between T's. Your screen should look like this:



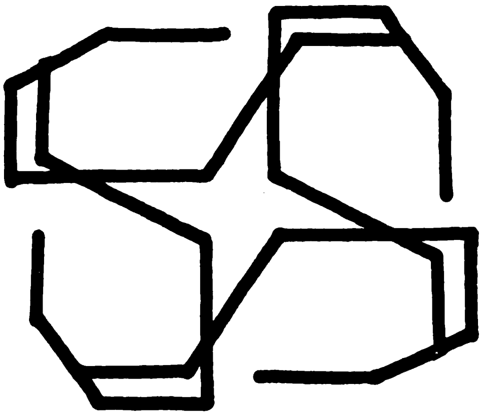
You should notice that the turtle starts drawing wherever you left it after doing the last command. Sometimes the turtle walks over the same old path. In that case, nothing new happens; the screen stays the same.

Here is another example of a repeated procedure. Susanna Sheldon wanted to design her initials, so she wrote this procedure for the letter S:

```
TO S
  BK 30
  RT 150
  FD 30
  LT 60
  FD 30
  LT 90
  FD 50
  LT 60
  FD 60
  RT 60
  FD 30
  RT 60
  FD 20
  RT 30
  FD 30
END
```



Since her last name also began with the letter S, she repeated the S and kept repeating until she came up with this design:



She called it STAR. Can you tell how many times she repeated the S?

ACTIVITIES

In the previous sections, you wrote procedures for some of the letters of the alphabet. Your precedures should now be loaded into the computer. If you have lost them, you can write new ones.

12. Pick one of these letters of the alphabet:

H T F I

Try repeating the letter over and over. Remember to leave a space after each letter or to hit return after each one. How many times did you repeat the letter? Sketch your design here. (Don't bother to make it exact.)

Did the turtle start to retrace a letter it had already made?

If so, how many times did you type in the letter before this happened? __________

Pick another letter and do the same thing.

Try to guess how many times you will repeat the procedure before the turtle traces over a letter.

13. Here are letters that have various angles. Choose one—either one you've already made or a new one.

A X Z Y V

If you're creating a new procedure, record it here and then define it on the computer.

Guess how many times you will need to repeat this procedure before the turtle retraces the letter. ____________________

Now repeat the letter until it makes a design. How many times did you repeat it? ____
Sketch your design here.

🔑 **14.** Try the letter N. Keep repeating it. What happens?

____

Sketch the results here:

🔑 **15.** Choose a design you like from the previous activities. Teach the turtle how to make the design by defining a new procedure. For example, Susanna wrote for hers:

```
TO STAR
  S S S S
END
```

A procedure such as the STAR procedure is called a *super-procedure* because it has other procedures for its commands. Name your super-procedure something simple and easy to remember, such as STAR or ZIGZAG. Record and sketch it here:

____

____

____

16. If you have a color monitor, you can change the pen color in between repeating the letters. Try something like this:

```
PC 2
U
PC 3
U
PC 4
U
```

Challenger

17. Not everyone will make the same letter the same way. See if you can invent three different procedures to make the letter W. Hint: Try changing the angles or the direction from which you start.
Record your procedures here. Name them W1, W2, and W3. Define them.

TO W1	TO W2	TO W3
________________	________________	________________
________________	________________	________________
________________	________________	________________
________________	________________	________________
________________	________________	________________
________________	________________	________________
________________	________________	________________
________________	________________	________________
________________	________________	________________
________________	________________	________________
END	END	END

Now repeat each of these procedures. Do the results all look the same?

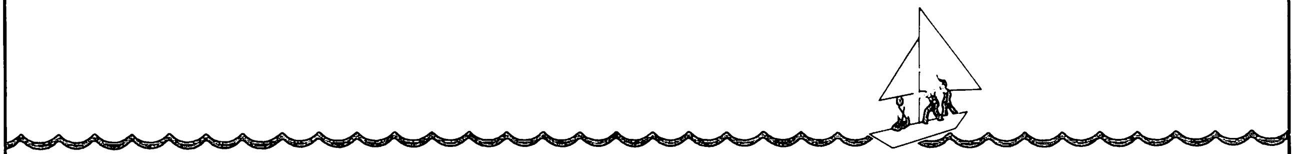
____

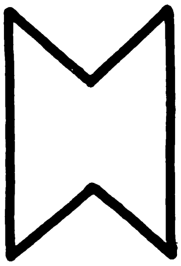
Sketch the results here:

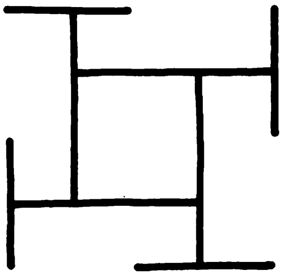
W1 design W2 design W3 design

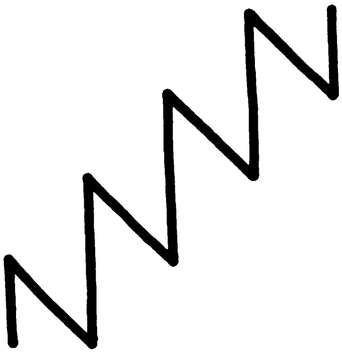
repeated ______ times ______ times ______ times

Note: Save your workspace under the same name as before, ''{name}LETTERS.









The REPEAT Command

After a while it gets to be a pain to keep typing in the procedure name over and over. Whenever you find yourself doing something over and over, you can guess that there will be a shortcut in Logo language. In this case, the shortcut is the REPEAT command. Like FD and RT it is a standard Logo command. The turtle already understands it, and you don't have to do any teaching.

Here's one example of the REPEAT command:

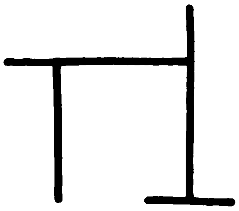
```
REPEAT 3 [L]
```

The number after REPEAT tells how many times something will be repeated. The number can involve a calculation such as 2 + 3 or 20 / 2 (just as with FD or RT). Next come brackets, [ ]. Whatever is in the brackets will be repeated by the turtle. This can be a procedure name (such as STAR), a single command (such as FD 10), a series of commands (such as FD 10 RT 30) or a series of procedure names and commands (such as STAR FD 30 STAR).

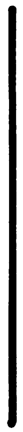
The close bracket (]) is the signal to the turtle that the list of commands is finished. The turtle will then do whatever is inside the brackets the number of times you gave.

Here are more examples of the REPEAT command:

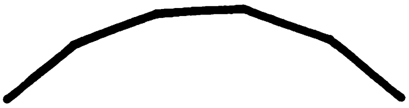
```
REPEAT 3 [T]
```



```
REPEAT 6 [FD 30]
```



```
REPEAT 5 [RT 30   FD 20]
```



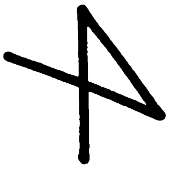
REPEAT COMMAND

REPEAT {a number} [{commands or procedures or both}]

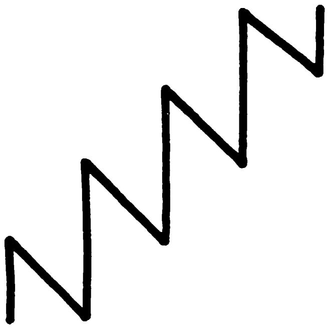
The REPEAT command repeats the commands and procedures inside the brackets the given number of times.

Examples:

1. REPEAT 3 [FD 30 RT 150]



2. REPEAT 4 [N]



ACTIVITIES

18. What will happen if you type in

```
    REPEAT 12 [RT 30] ?
or  REPEAT 10 [BK 10] ?
or  REPEAT 12 [H] ?
```

Sketch your guesses here: Sketch the actual results here:

🔑 **19.** Shorten these commands by using the REPEAT command:

```
FD 20
RT 30
FD 20
RT 30
FD 20
RT 30
```

Record your new command: ____

20. Remember the dotted line you drew in Chapter 3? The pattern went

```
FD 2   PU   FD 4   PD   FD 2   PU   FD 4   PD
```

Use the REPEAT command to make a dotted line up and down the screen. Record your command line here:

____

21. Load in your file by typing in

```
READ "{name}LETTERS
```

and use the REPEAT Command to make a pattern with one of these letters:

W N Y V M

Sketch the result here:

22. This time put a procedure and a command inside the brackets. Try these examples:

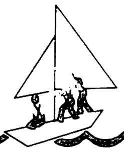
```
REPEAT 6 [W   RT 30]
REPEAT 12 [{any letter}   RT 30]
```

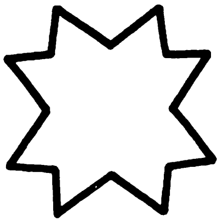
Try one again, change only the angle or the order. For example,

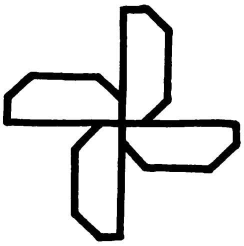
```
REPEAT 6 [RT 30   W]
```

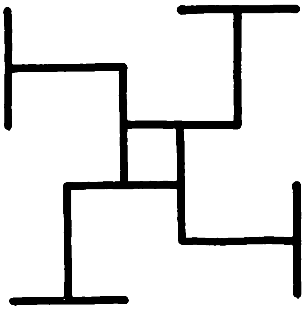
Sketch the new result here:

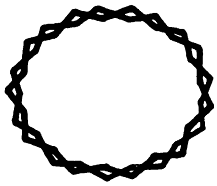
Note: You don't need to save the workspace, since no new procedures were defined.





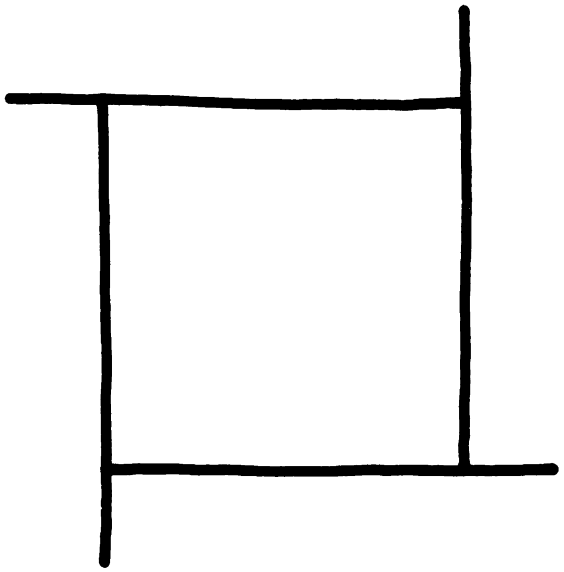






Using the REPEAT and PRINT Commands in Procedures

The REPEAT command can be used in a procedure. Instead of typing REPEAT 4 [T] all the time, we could define a new procedure, say T. DESIGN. (Don't forget that you can't use a space in a procedure name. If you want two words, you have to use a period to connect them.)



```
TO T. DESIGN
  REPEAT 4 [T]
END
```

You have now begun to write super-procedures that can use the procedures you have taught the turtle as well as the commands FD, BK, RT, and LT, etc. The turtle is getting a larger and larger vocabulary.

The PRINT Command

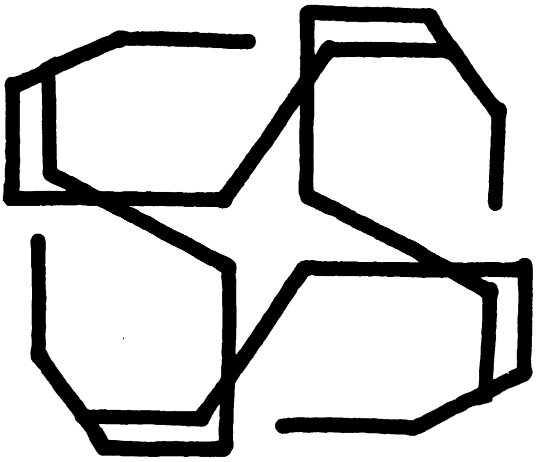
When Susanna's STAR drawing appeared on the screen, her friend said, ''That's pretty, but what is it?''

Susanna wanted to be able to label the drawing. That is easy to do. You just add a PRINT command at the end of your procedure, like this:

```
TO STAR
  REPEAT 4 [S]
  PRINT [STAR MADE OUT OF S'S, BY SUSANNA]
END
```

Note: Keep typing even if you go past the end of the line. If you press <RETURN> during a PRINT command, you will have problems.

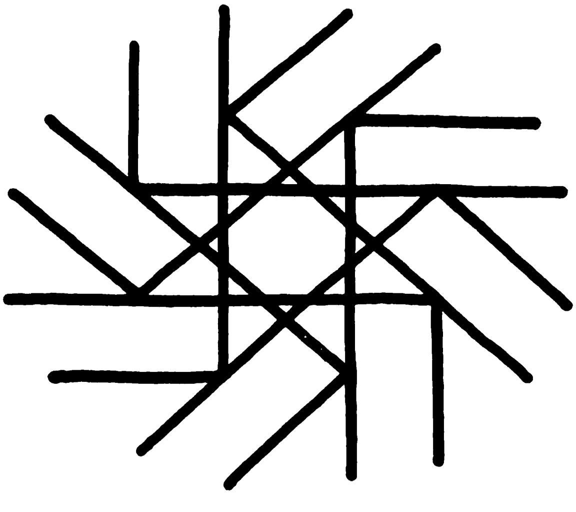
Susanna's drawing will now look like this:



```
STAR MADE OUT OF S'S, BY SUSANNA
?
```

Whatever is inside the brackets after PRINT will be printed in the bottom five lines of the Splitscreen. You can use a PRINT command to label and explain your picture, as Susanna did, or to print a message. Here's an example:

```
TO WEB
  REPEAT 8 [K]
  PRINT [HEY, THAT'S EXCELLENT!]
END
```



```
HEY, THAT'S EXCELLENT
?
```

PRINT

PRINT [{a list of words}]
PR {{a list of words}]

Prints out whatever is contained in the brackets.

Examples:

1. PRINT [HI AND HELLO!]
will produce
HI AND HELLO!
2. PRINT [ ]
will produce a blank line.

PRINT can be used in Direct Mode or inside a procedure.

ACTIVITIES

Make sure your {name}LETTERS file is loaded in the computer.

🔑 **23.** Make a design from one of your letters by using the REPEAT command. Give the design a name, and define it as a super-procedure. Record the procedure here:

TO

____

____

____

END

24. Take a letter such as I, H, or A. Make a design that uses the REPEAT command like this:

```
REPEAT 4 [A   FD 20]
```

How is the design different from the one made by

```
REPEAT 4 [A]?
```

Find a design you like, name it, and define it as a super-procedure.
Record the super-procedure and sketch the results.

TO

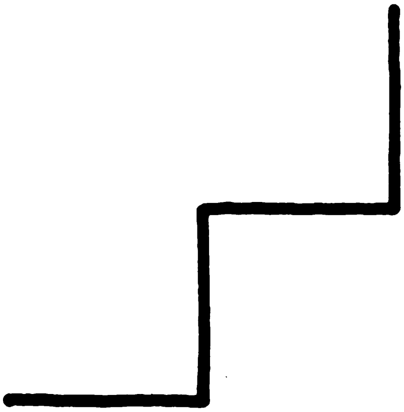
____

____

____

END

25. To make this pattern:



you would type in:

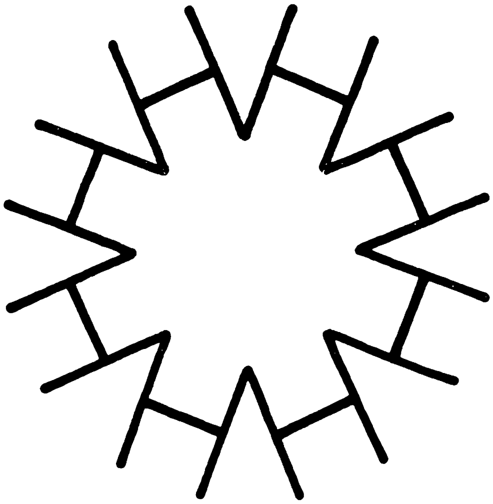
```
RT 90   FD 20   LT 90   FD 20
RT 90   FD 20   LT 90   FD 20
```

Write it in an easier way, using the REPEAT command.

____

Can you make the pattern fill the screen?

26. Can you think of a procedure using the REPEAT command that will make this design?
Hint: It is made out of this H procedure.



```
TO H
  FD 50
  BK 25
  RT 90
  FD 25
  LT 90
  FD 25
  BK 50
END
```

Add a PRINT statement at the end of your super-procedure. Record it here:

____

____

____

____

27. The REPEAT command comes in handy especially when you have a long list that you want repeated.
Experiment with FD, LT, and RT to make a strange shape. Use at least seven commands. List the commands here:

____

Now see what happens when you repeat this shape. Make a new procedure.

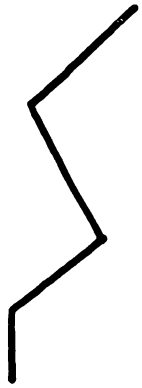
```
TO STRANGE.SHAPE
  REPEAT 12 [{list your commands here all on the same line]}
END
```

Have the turtle draw your strange shape. What happened?

Here's an example:

```
FD 2   RT 8   FD 4   LT 24   FD 14   RT 50   FD 11
```

looks like this:



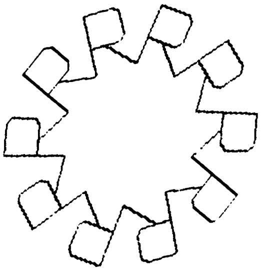
When a procedure is made for it, it looks like this:

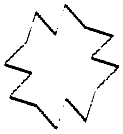
```
TO STRANGE.DESIGN
  REPEAT 21 [FD 2   RT 8   FD 4   LT 24   FD 14   RT 50   FD 11]
END
```

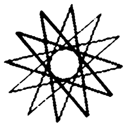
Be sure to keep typing in the commands even if you go past the end of the line. If you press the <RETURN> key during a REPEAT command, you will run into problems.

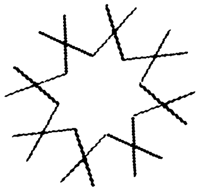
Note: When you are finished at the computer, save your workspace under the same name, {name}LETTERS.

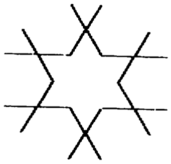
Chapter Four

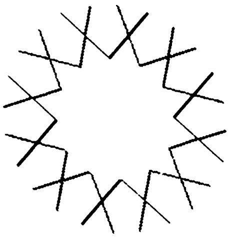


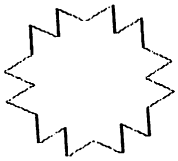


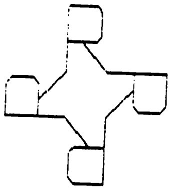


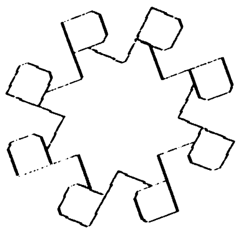












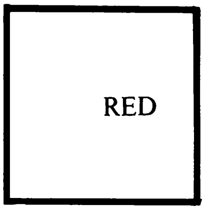
The STAMPCHAR Command

You already know how to print words like HEY, THAT'S EXCELLENT! This sentence appeared on the text (bottom) portion of the screen. You can also place letters or other characters (*,#,$, etc.) on the graphics portion by using a special command, STAMPCHAR. To print the letter R, type

```
STAMPCHAR “R
```

Wherever the turtle happens to be, it will stamp this letter on the screen. To see the letter clearly, you will need to hide the turtle (HT). If you want to stamp another letter, you can move the turtle with the regular drawing commands and then stamp letters anywhere on the screen. Supposing you want to write the word RED. The following commands would work.

```
STAMPCHAR “R
RT 90
PU
FD 10
STAMPCHAR “E
FD 10
STAMPCHAR “D
HT
```



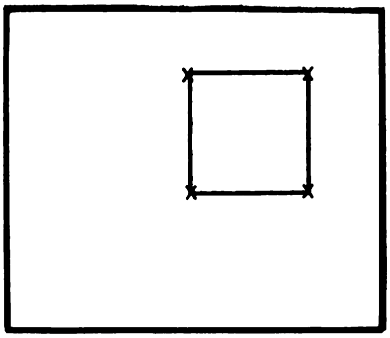
Did you notice that the pen does not need to be down to stamp a character? Stamping and drawing work independently. In the example above, we did not want lines drawn between the letters of RED so we lifted the pen before stamping the first letter.

Letters are *always* stamped right side up, no matter what direction the turtle is pointing. This makes life easier for you if you are moving the turtle to many places on the screen. You don't need to head it to the top of the screen before you stamp a new character.

Note: You could even make the letters red by typing the PC 2 command before stamping the first letter.

If you wanted to *draw* a large box with an X at each corner, you could use these commands.

```
STAMPCHAR "X
RT 90
FD 80
STAMPCHAR "X
LT 90
FD 80
STAMPCHAR "X
LT 90
FD 80
STAMPCHAR "X
LT 90
FD 80
HT
```



Note: Yes, you can use DOUBLECOLOR to stamp characters, but the letters are difficult to read. It's best to stay in SINGLECOLOR.

STAMPCHAR

STAMPCHAR “{a letter or other text character}

This command places text on the graphics portion of the screen. The quotation mark (“) is necessary. Without it, Logo would want to run a procedure.

Examples:

```
STAMPCHAR “H
HT                    will make   H
```

```
STAMPCHAR “H
PU
RT 90
FD 10
STAMPCHAR “I
FD 10
STAMPCHAR “!
HT                    will make   HI!
```

STAMPCHAR can be used in Direct Mode or inside a procedure. You can stamp characters in color by using PENCOLOR (PC) commands. Characters are always stamped in an upright position. Characters can be stamped when the turtle’s pen is up. This is because characters are “stamped,” not “drawn.”

Note: There is a file called STAMPER on your Logo Utilities disk that allows you to print an entire sentence on the graphic screen. You can learn about it in your *Commodore Logo Manual.*

Chapter Four

ACTIVITIES

28. Use STAMPCHAR to put your initial in the four corners of the screen. Do it without letting any lines show between initials.

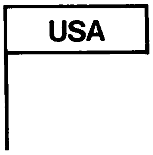
Sketch

29. Make any shape you like in one color. Then stamp your initials in another color inside the shape.

Commands

Sketch

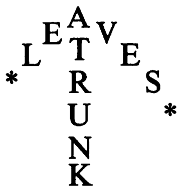
30. Choose a drawing for which you already have a procedure. Or, if you like, use this sketch. Using STAMPCHAR inside your procedure, add some letters to your drawing.



Procedure

Sketch

31. Make a picture out of letters and/or other characters. Here's an idea.



Procedure

____

____

____

____

____

____

____

____

Sketch

32. Make a simple crostic.

I

L O V E
O
G
O

Procedure

____

____

____

____

____

____

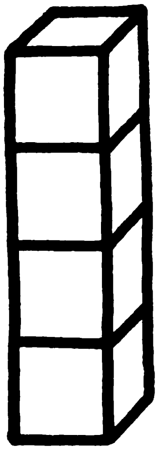
____

____

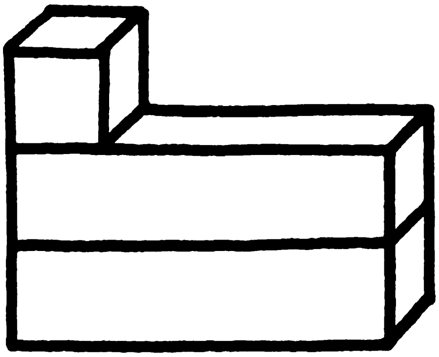
Sketch

Combining Procedures

Procedures are like building blocks. You can take blocks of simple shapes and combine them to make more complex shapes. We've just seen how you can take a number of identical procedures to build something new. Your T's gave us a T.DESIGN. That's something like taking four identical wooden blocks to build a tower.



We could also build something out of two or more different types of blocks, say cubes and rectangle blocks.



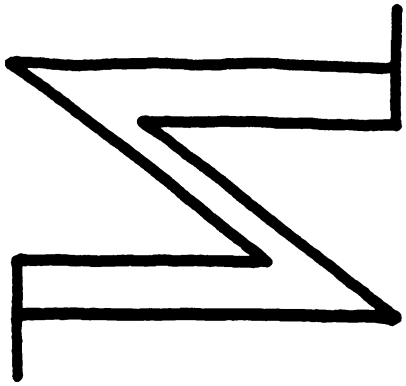
In Logo we can combine several procedures to create new designs. For example, Jenny and Walter worked together and made the letters T and Z. Here are their procedures:

```
TO T
  FD 30
  LT 90
  FD 10
  RT 180
  FD 20
END
```

```
TO Z
  RT 90
  FD 50
  LT 150
  FD 60
  RT 150
  FD 50
END
```

They decided to repeat their letters together in a pattern rather than going T T T T or Z Z Z Z. This is what happened when they went

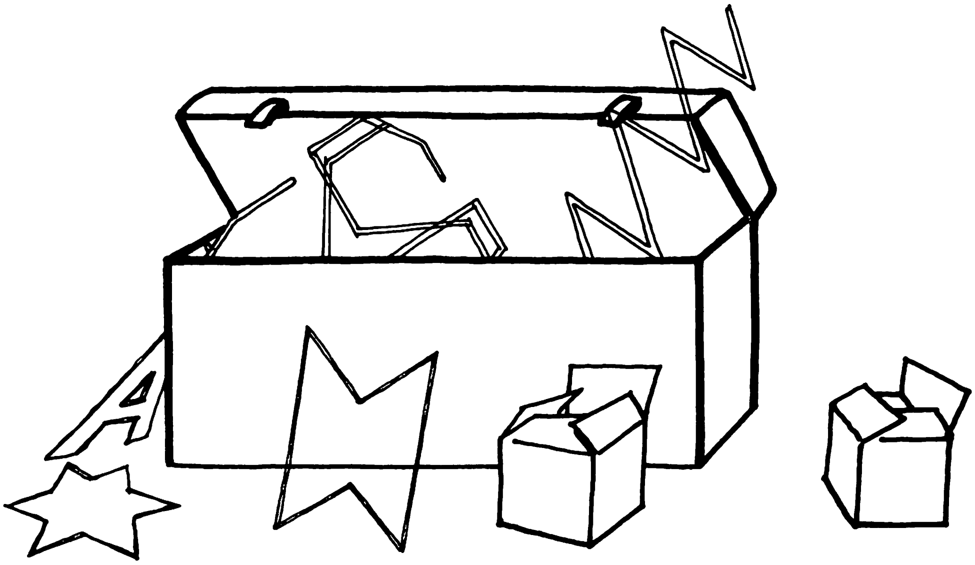
Z T Z T



Would this design change if they repeated Z T again? ______________________

What would have happened if they had typed T Z T Z? ______________________

You can think of all the procedures you've written as your own box of materials that you can use in your workshop to make more designs and creations.



Experiment with the procedures you have written so far. In the next chapter, you'll define some new ones to make various boxes of materials.

ACTIVITIES

Read your letter file into the computer once more by typing

READ "{name}LETTERS

33. Choose any two of your letter procedures, and repeat them in a pattern.

Which letters did you choose? ____________________ ____________________

Show what you typed in. ____

How many times did you repeat each letter? ______________________________

Did you like the design? _______________

Sketch the design here:

Try other combinations of letters.

Which two letters together make your favorite design? ______________________

Sketch your favorite design.

34. Write a super-procedure to make the design you liked best.
Here is what Jenny and Walter may have done:

```
TO ZT
  REPEAT 2 [Z T]
END
```

Record your new procedure here:

```
TO
  ______________________________
  ______________________________
  ______________________________
END
```

35. Now invent two new procedures. Try letters from previous sections or make up a new way to draw an old letter. Record your ideas below. Define the procedures at the computer.

Procedure 1	Procedure 2
________________________	________________________
________________________	________________________
________________________	________________________
________________________	________________________
________________________	________________________
________________________	________________________
________________________	________________________
________________________	________________________
________________________	________________________
________________________	________________________
________________________	________________________
________________________	________________________

Stage two is to combine these two new procedures in a pattern to create a new design—Procedure 3!

Procedure 3

____

____

____

____

____

____

____

____

____

____

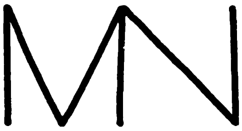
____

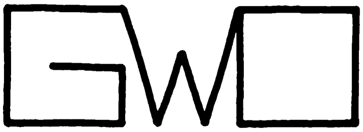
____

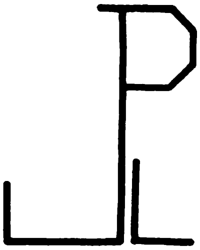
Did you like your result?______________Sketch it here.

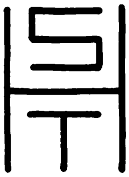
Try reversing the letters. How does that look?

36. Make up a monogram out of your first and last initials (middle, too, if you like!). Experiment with the spacing and size of the letters to get a monogram you like. Add color if you can. Here are some pictures to give you ideas:









Record your procedures here.

First Initial	Middle Initial (optional)	Last Initial

Monogram

____

____

____

____

____

____

____

____

____

____

____

____

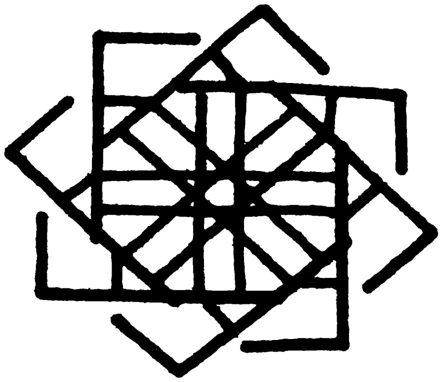
37. You are now ready for a big step forward in the number of designs you can create. Try combining more than two letters. For example, here are three procedures:

```
TO F
  FD 30
  RT 90
  FD 15
  BK 15
  RT 90
  FD 15
  LT 90
  FD 10
END
```

```
TO V
  LT 45
  FD 20
  BK 20
  RT 90
  FD 20
END
```

```
TO I
  LT 90
  FD 10
  BK 20
  FD 10
  RT 90
  FD 30
  LT 90
  FD 10
  RT 180
  FD 20
END
```

When they are repeated in this order, F V I, this design occurs after eight repeats.



Pick any three letters of your own and repeat them in a pattern. If you don't like the design, arrange the letters in a different order. When you like a design, name it and define a super-procedure to make it. Record your super-procedure and the design it makes here:

TO

____

____

____

END

Challenger

38. Go back to Jenny and Walter's ZT design on page 113. Type in their procedures for T and Z, but call them T1 and Z1. See if you can invent new ways to make the letters T and Z, calling your procedures T2, T3, Z2, Z3, etc.

Hint: Think about proportion and angles.

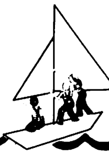
Combine the various T's and Z's in many ways. For example, you could type

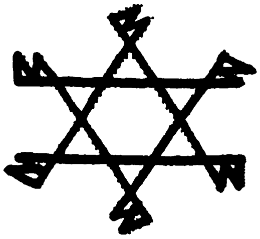
T2 Z1 T2 Z1 or T3 Z2 T3 Z2

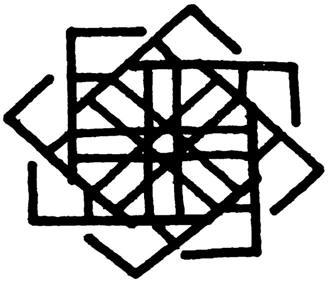
How many ZT or TZ designs can you create? Sketch the ones you like best below.

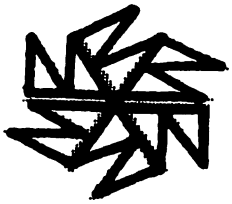
Label your sketches by writing underneath them the procedure you defined for each one.

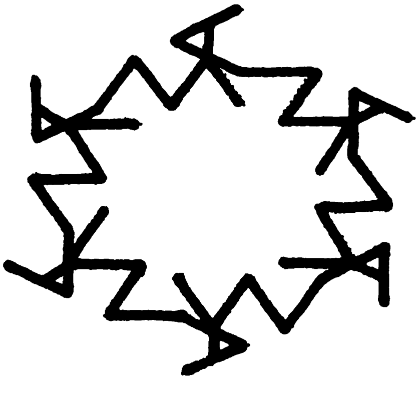
Note: Save your workspace by typing
SAVE "{name}LETTERS

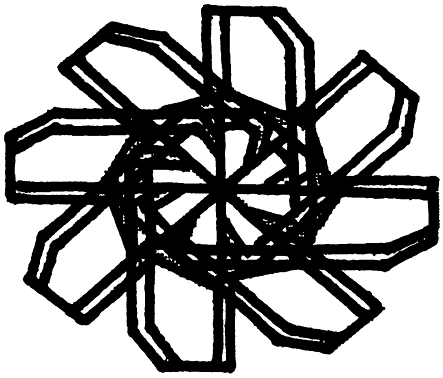








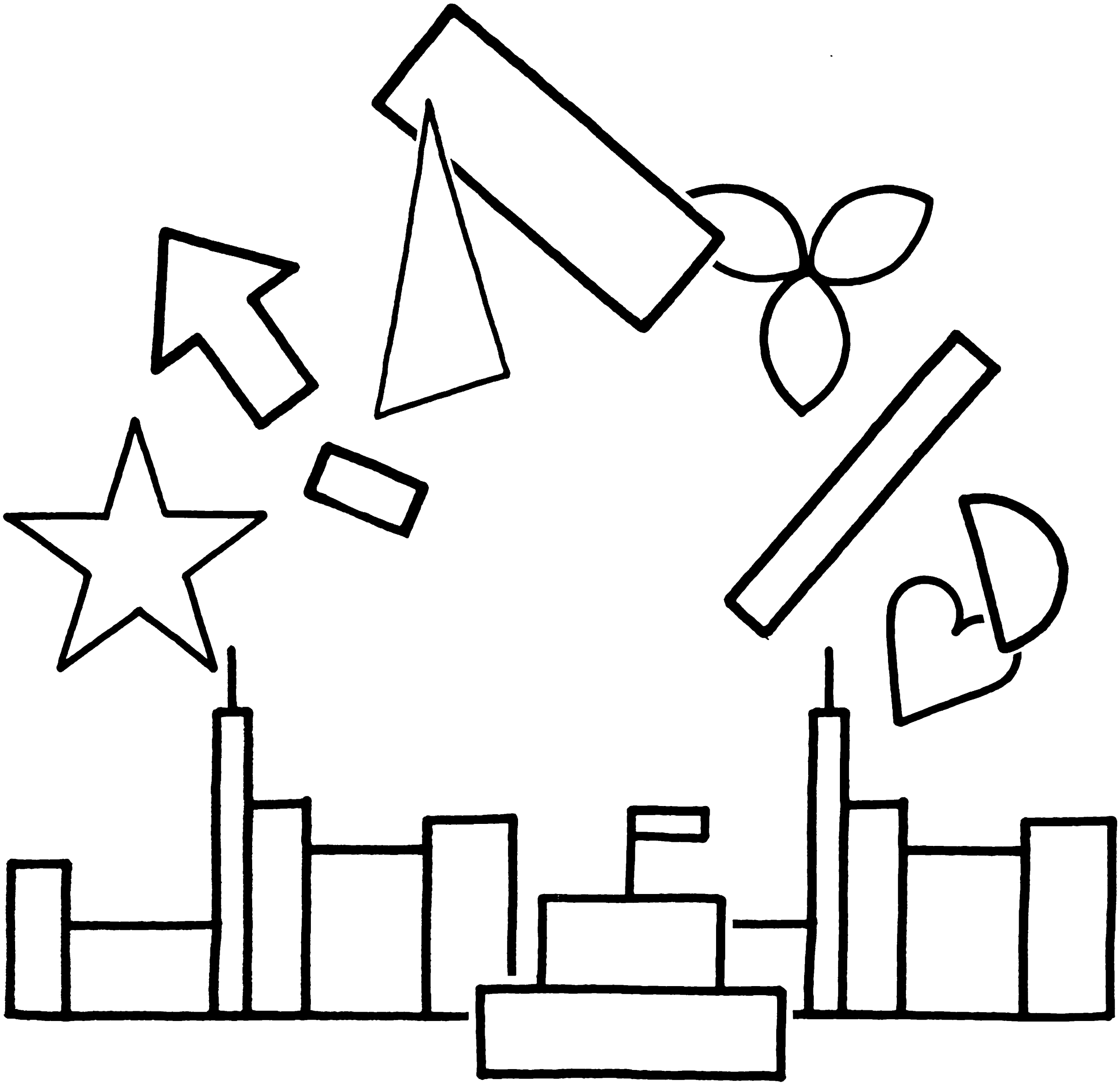




CHAPTER

FIVE

Shapes



Chapter Five

Making Up Shapes

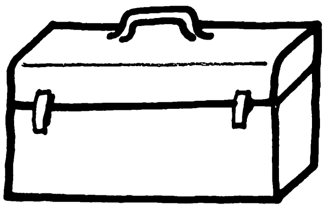
Introduction to Chapters Five and Six

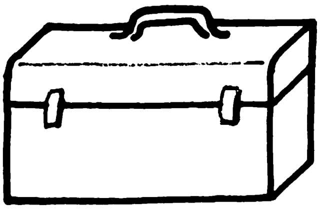
The next two chapters go together. In Chapter Five you make shapes, and in Chapter Six you make designs out of them. We have put the various types of shapes in Chapter Five so that you will know where to find them when you want to learn about them. We don't expect you to go straight through Chapter Five. Once you've defined some shapes, you will probably want to make designs out of them right away. You can skip to Chapter Six to make designs. Then when you find you want to have another shape to build with, you can go back to Chapter Five.

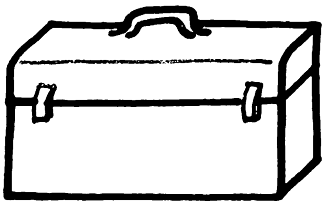
We recommend that you finish the first two sections of Chapter Five before you go to Chapter Six. After that, you can hop back and forth as much as you like.

Types of Shapes

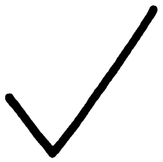
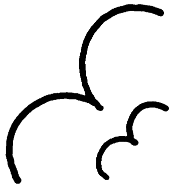
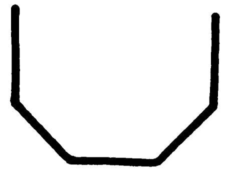
You could continue making designs out of letters, but you can make a lot more designs if you know how to make some basic shapes and can use them to build designs. Procedures you write for shapes will be like more materials at your computer workbench. If you imagine that your shapes will be like pieces of cloth, you can see that you'll want to have lots of types of cloth to choose from: cotton and corduroy and silk and solid colors and prints. In the same way, you'll want to have lots of types of shapes to work with: squares, rectangles, triangles, circles, and odd shapes, too.



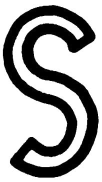
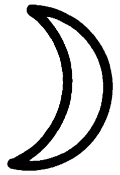
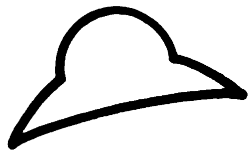
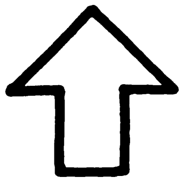




Think about shapes for a minute. The letters you've been working with are shapes, too. Most letters such as T and H are what are called *open* shapes; O and D are *closed.* A closed shape has an inside and an outside; an open shape doesn't. Here are some sketches of open shapes:

Here are some sketches of closed shapes:

You see some closed shapes, such as circles, squares, and triangles, over and over again. They are so common that they have special names and definitions. You probably have learned something about them in other classes.

Closed shapes with many sides are called *polygons*. The name, polygon, comes from two Greek words: *poly,* meaning many, and *gon,* meaning sides. A *regular* polygon is one with equal sides and equal angles. A square is an example of a regular polygon. It has four equal sides and four angles of 90° each. Regular polygons are great for building designs. They are also useful for drawing pictures of everyday objects such as cars, flowers, and houses.

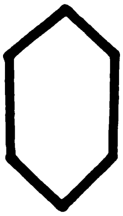
In the next section, you'll learn how to make regular polygons. Then you'll explore circles and curves. In the last part of this chapter, you'll work with a variety of shapes, including rectangles, parallelograms, trapezoids, and triangles. Throughout the chapter, we encourage you to play with shapes and see what else you can make out of them.

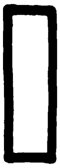
Before you go to the next section, take some time to draw some simple shapes at the computer, such as the ones above or ones you make up yourself. This is a chance for you to be an explorer on your own without a guide. Fiddle around and see what you come up with. If you have trouble figuring out how to make shapes, just go on to the next section on polygons.

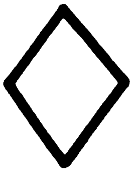
Warning: Keep your procedures short! If you make up something very involved and long, you will have trouble finding mistakes. You can find lots of interesting shapes that don't take a lot of commands to make. A good rule of thumb is to make sure the list of commands fits on the screen in Edit Mode.

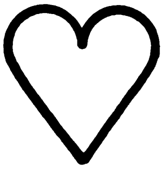
Chapter Five

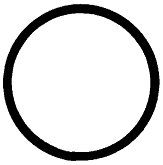
ACTIVITIES











1. Experiment at the computer in Direct Mode, making up as many shapes as you like. Choose your three favorite ones. Record and sketch them below. Remember to keep the procedures short.

Procedure

Sketch

Procedure

Sketch

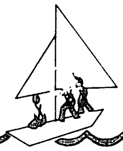
Procedure

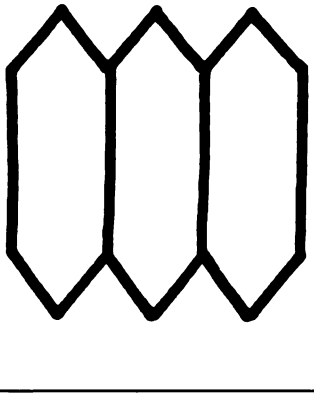
Sketch

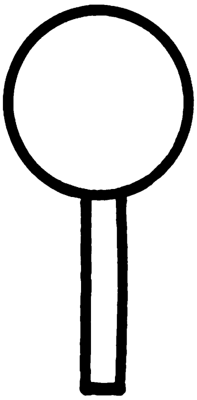
2. Use your shapes to make pictures or designs. You can try repeating a shape or combining several shapes as you did with your letters in Chapter Four. Add a PRINT statement at the end of your procedure or put letters in your design with STAMPCHAR. Show your best results here:

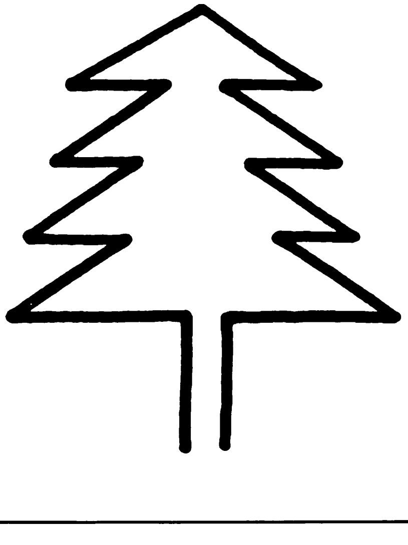
Procedures

Sketch







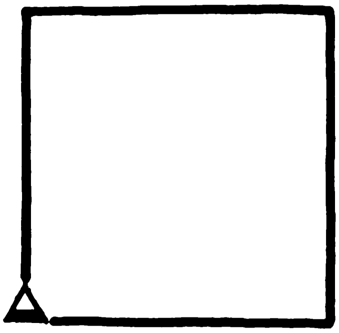


Chapter Five

Regular Polygons

The simplest regular polygon to make is a square. You probably have drawn one already on your own. Here is one procedure for a square:

```
TO SQUARE
  FD 50
  RT 90
  FD 50
  RT 90
  FD 50
  RT 90
  FD 50
  RT 90
END
```



Do you see a pattern in this procedure? Since squares have four even sides and four right angles, we repeat the same steps (FD 50 RT 90) four times. We can take a short cut and use the REPEAT command, like this:

```
TO SQUARE
  REPEAT 4 [FD 50   RT 90]
END
```

How would you make a regular six-sided figure, a hexagon? You know that if you need six sides you'll have to REPEAT six times. So try this:

```
TO HEXAGON
  REPEAT 6 [FD 50   RT 90]
END
```

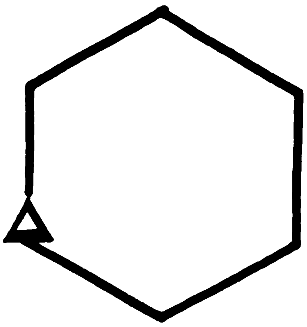
What happens? You didn't get six sides; the turtle just walked over the first two sides twice. What's wrong? Six repeats is right. You could try changing FD 50 to FD 30. Does that help? Why not? Try changing the angle. Do you think the angle should be bigger or smaller? Experiment with various angles until you get a hexagon. (Your Degree Finder may help.)

Write the procedure here:

TO HEXAGON

____

END



ACTIVITIES

Save the procedures for this chapter as "{name}.SHAPES anytime you leave the computer. The next time you start you can just READ in your file.

🔑 **3.** Follow the same process to define an octagon. It will have eight equal sides (Octagons are great for building designs.)

TO OCTAGON

____

END

4. Do the same thing for shapes with 10 sides (decagons) and 12 sides (dodecagons).

TO DECAGON

____

END

TO DODECAGON

____

END

5. Fill in the chart below with the information about various polygons. Use your Turtle Clock to figure out how many degrees in all the turtle turns. Add on the degrees for every turn the turtle makes. (You can ignore how far the turtle is going forward or backward; just keep adding the degrees it is turning.)

Sides	Repeats	Degrees in Each Turn	Total Number of Degrees the Turtle Has Turned
4	______	______	______
6	______	______	______
8	______	______	______
10	______	______	______
12	______	______	______

By now you should be seeing a pattern. How do you figure out the angle size?

____

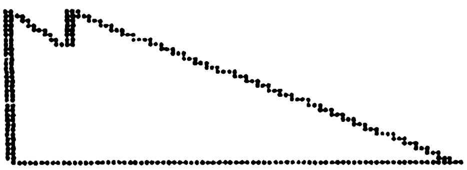
____

Just in case you couldn't figure out the pattern, we'll tell you. The general rule will be a big help to you.

The number of repeats multiplied by the number of degrees in one turn will always = 360°. Put another way, the number of degrees in one turn = 360 / the number of repeats.

If you think about it, you'll understand that the turtle has to complete a 360° turn as it traces out each polygon shape. Use your Turtle Clock to watch how this works. Start the turtle at 12:00. Type in the commands below, moving the turtle on the clock each time you give a turning command to the screen turtle. (You don't move the turtle on the Turtle Clock when you give FD or BK commands.)

```
FD 40
RT 135
FD 15
LT 135
FD 10
RT 120
FD 80
RT 150
FD 80
RT 90
```



By the time the turtle on the screen is finished tracing out the shape, the turtle on the clock will be back to 12:00. Both turtles have turned 360°. The screen turtle is standing exactly where it started, facing in the same direction. Because we know the turtle has made a complete rotation or trip, we also know that it must have turned 360°. This is called a *Total Turtle Trip*.

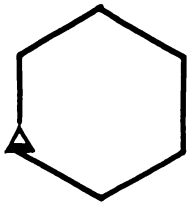
TOTAL TURTLE TRIP

If you want the turtle to draw a shape and end up exactly in the *same place* it started, heading in the *same direction*, you must make the turtle turn a total of 360° (or a multiple of 360°).

The turtle's complete journey back to its exact beginning position is called a Total Turtle Trip.

Examples:

1.
```
TO HEXAGON
  REPEAT 6 [FD 30   LT 60]
END
```

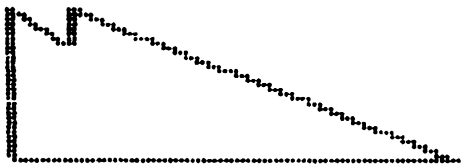


(Note that 6 (the number of sides) times 60 (the number of degrees) equals 360.)

2. This procedure can be used to draw any regular polygon.

```
TO POLYGON
  REPEAT {number of sides} [FD {any number} RT 360 / {number of sides}]
END
```

3.
```
TO MOUNTAINS        (total degrees turtle has turned)
   FD 40
   RT 135           0   + 135 = 135
   FD 15
   LT 135           135 - 135 = 0
   FD 10
   RT 120           0   + 120 = 120
   FD 80
   RT 150           120 + 150 = 270
   FD 80
   RT 90            270 +  90 = 360
  END
```



Note: The RT 135 and LT 135 cancel each other out because right and left are opposites. The FD steps don't affect the total number of degrees the turtle has turned.

ACTIVITIES

🔑 **6.** Now that you know that 360° is the magic number, figure out the procedures for these shapes:

equilateral triangle ____________________

pentagon (5-sided polygon) ____________________

septagon (7-sided polygon) ____________________

nonagon (9-sided polygon) ____________________

7. So far we have used FD and RT in our examples. Try to figure out some different ways to make the same shapes. For example, design a square that uses BACK instead of FORWARD or turns LEFT instead of RIGHT. Choose a name like BACKSQUARE or LEFTSQUARE for your new shape.

Procedure	Sketch
____________________	
____________________	
____________________	
____________________	

Procedure	Sketch
____________________	
____________________	
____________________	
____________________	

8. What happens if you put the turn first when you write the REPEAT? The hexagon would become REPEAT 6 [RT 60 FD 50]. Try this with a few of your procedures. What happens?

____

9. Pick one of your shapes and change its size. Make it bigger, and then make it smaller. Record the procedures here:

TO SMALL ____________________

____

____

END

TO BIG ____________________

____

____

END

10. If the turtle turns 360° + 360°, it rotates all the way around twice but still makes a total trip and still gets back to where it started from. Here's a command for a polygon that divides up into 720° instead of 360°. What does it make?

```
REPEAT 5 [FD 50   RT 720 / 5]
```

Sketch

Experiment with some other numbers.

11. Write a procedure for a 20-sided figure and a 30-sided figure. After you figure them out, try them out on the computer. Do they look like what you expected?

TO TWENTYGON

Sketches

____

____

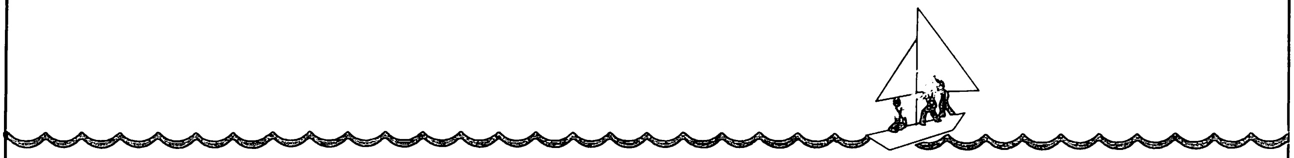
END

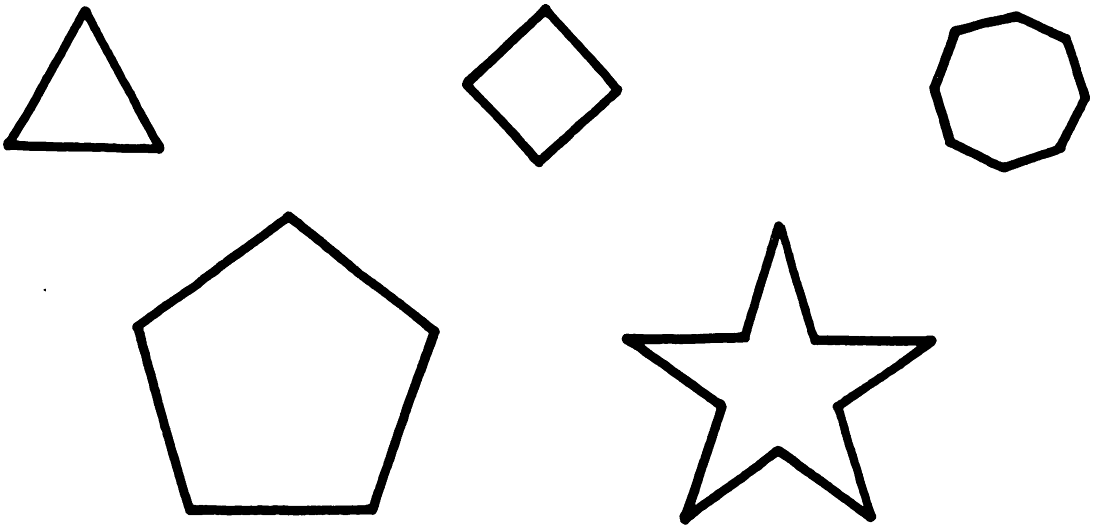
TO THIRTYGON

____

____

END





Note: You can skip ahead to Chapter Six now to make designs out of your polygons, or you can go on to the next section.

Circles and Curves

Circles and Arcs

Surprise!! You've made a circle! A polygon with enough sides looks so much like a circle, you can't tell the difference between the two. In fact, one definition of a circle is a polygon with an infinite number of sides.

Another way to think about circles is to figure out how you or the turtle would walk in a circle. Try drawing a part of a circle on the floor with chalk or tape. Play turtle, as you did in Chapter Two. The "commander" must get the "turtle" to walk along the curve. What commands work? (Hint: The turtle must somehow turn as it moves forward.)

____

____

What commands do you need to complete a circle? ________________________

____

How do your commands above compare with the commands for a 30-sided polygon? What's the same, and what is different?

____

____

Sometimes when people learn about the Total Turtle Trip, they think, "Aha! Now I know how to make a circle!"

```
REPEAT 360 [FD 10   RT 1]
```

This does work (try it and see), but it has some problems—it's way too big, and it takes forever to make. Making the steps smaller (FD 1 instead of 10 or 50) helps, but you really need to speed things up.

One way is to hide the turtle (with the HT command). Drawing is always quicker when you hide the turtle.

Another way is to use what you just learned in the last section. Once a polygon on the computer screen gets about 18 sides, it looks just like a circle.

ACTIVITIES

12. Experiment at the computer in Direct Mode until you get a circle you like.

Define it.

TO CIRCLE

____

____

____

Sketch it.

13. Try making your circle smaller or larger by changing the size of the FORWARD step in your REPEAT command.

Old Circle	New Circle
______________________________	______________________________

14. Change your circle by making a left turn instead of a right (or right instead of left).

Right Circle	Left Circle
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________

15. Define arcs to show these parts of a circle:

semicircle (top)	◠	______________________________
semicircle (bottom)	◡	______________________________
semicircle (west half)	(	______________________________
semicircle (east half)	)	______________________________
quarter circle	◜	______________________________
third of a circle	)	______________________________

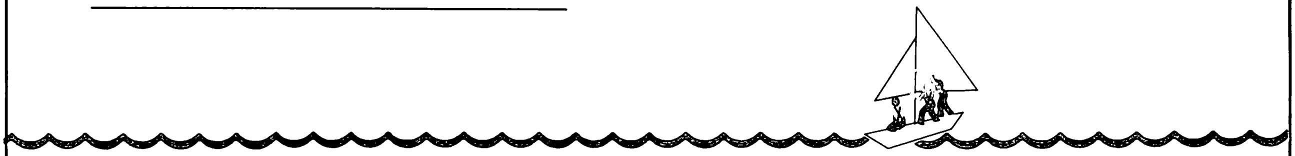
16. Make up a design using your arcs. You may want to experiment with a combination of arcs turning left and arcs turning right. Add color if you wish.
TO ARCDESIGN

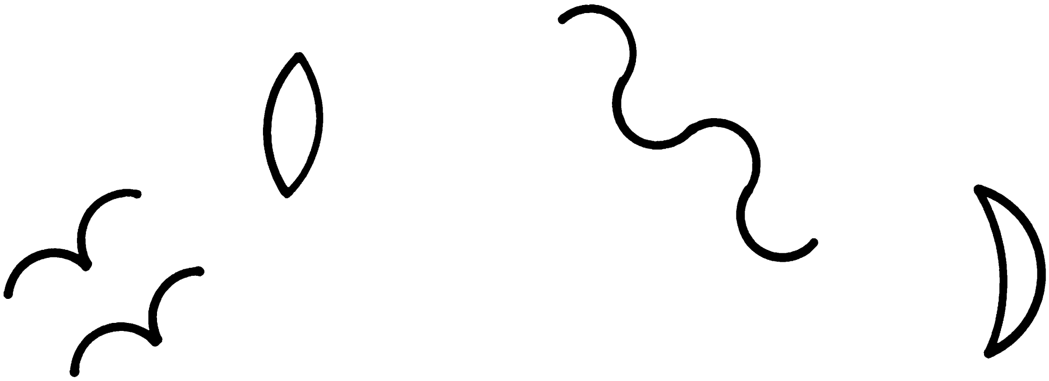
____

____

____

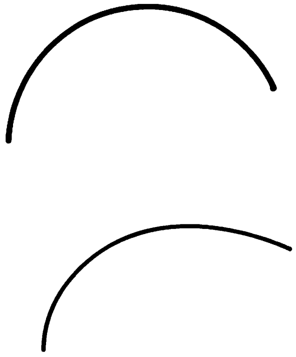
____





Curves

An arc is just a part of a circle. A curve is one or more arcs joined together.



Some curves are sharp ; some are more like straight lines . What makes the difference? Try walking along some sharp and gentle curves before you try these activities. You can also try drawing different curves first with your Turtle Pen. As you're walking or drawing curves, pay attention to the sizes of steps and turns.

ACTIVITIES

17. Experiment in Direct Mode, drawing several curves. Define a few of the curves you like and sketch them here:

18. Here is a procedure for a curve:

```
TO CURVE1
  REPEAT 2 [FD 25   RT 5]
  REPEAT 5 [FD 10   RT 15]
  REPEAT 2 [FD 25   RT 5]
END
```

Change it to make the curve sharper.

```
TO SHARPCURVE
```

19. Take CURVE1 and make it a more shallow curve. Record the new procedure, and sketch your curve.

Procedure Sketch

____

____

____

____

____

20. Draw one of the curves you have designed. Can you figure out how to back up along the same line?

Write your backwards procedure here.

TO BACKCURVE

____

____

____

____

____

You can check your backwards procedure at the computer by typing

```
{curve procedure name}
PENERASE
{back-up procedure name}
```

Your curve should be erased.

21. Make up a new design, using a combination of straight lines and curves.

Procedure Sketch

____

____

____

____

____

____

22. Make one or more of the curved or partly curved letters of the alphabet, such as S or D, using arcs.

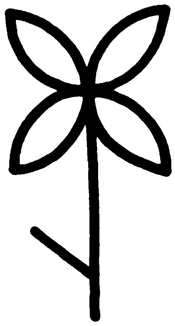
Procedure

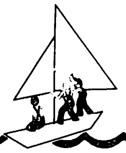
Sketch

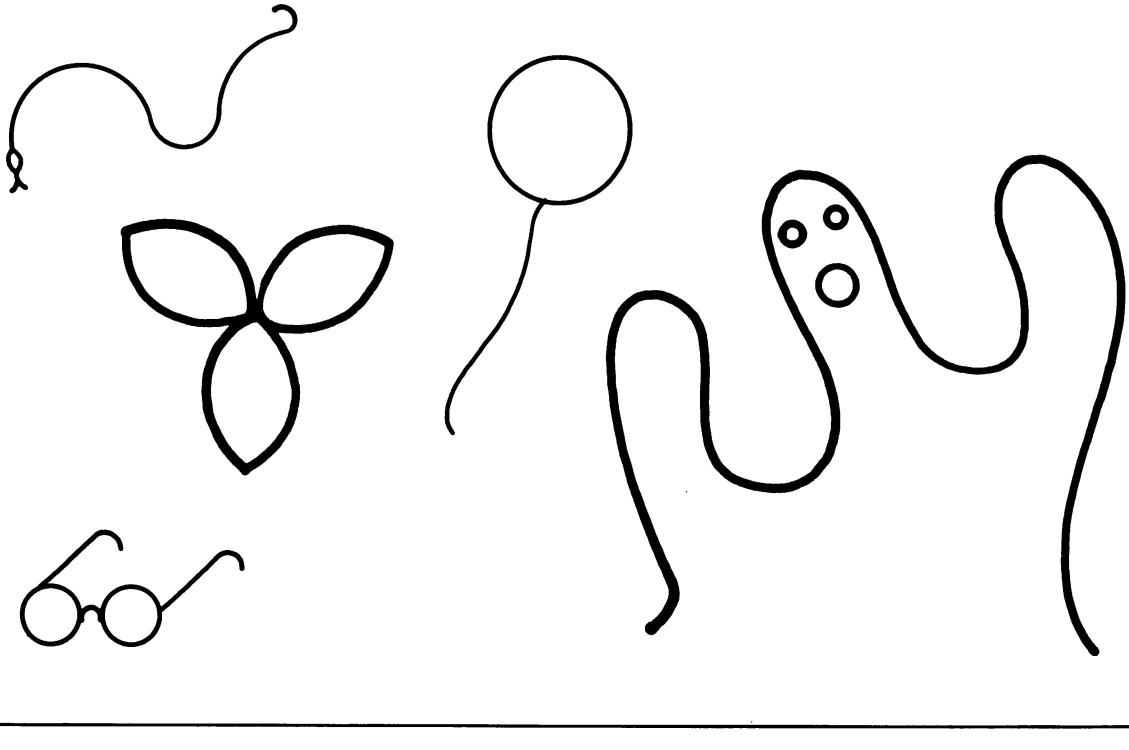
23. Make a drawing of an everyday object that has curves, such as a flower or a cup. Keep it simple and short!

Procedure

Sketch







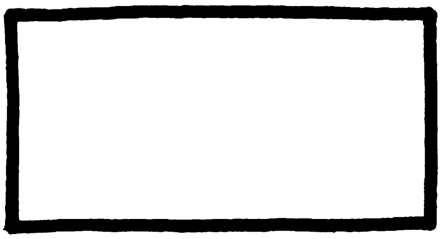
Chapter Five

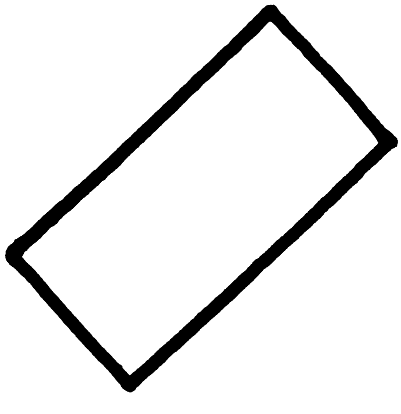
Other Shapes

Now that you know how to make curves and regular polygons, you'll be able to make a lot more shapes and drawings than when you first tried. In this section, we divide the shapes into categories and show you starting examples for each one. Then it will be up to you and your imagination to create and explore to your heart's content.

Rectangles

Rectangles are easy to make. Just remember that all the angles are 90° and that the opposite sides have to be the same length.





ACTIVITIES

24. Make a medium-sized rectangle in Direct Mode and define a procedure for it.

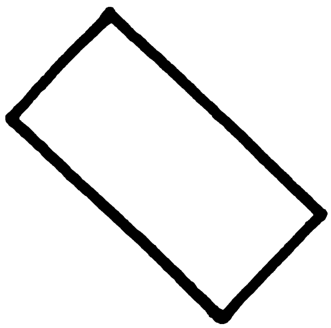
Procedure

Sketch

25. Experiment with the way your rectangle is standing. Try making it go sideways, up and down, or diagonally (on a slant). Record one of your experiments.

Procedure

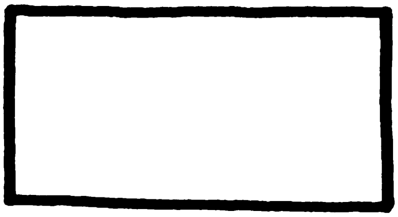
Sketch

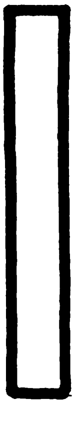


26. Experiment with changing the size of your rectangle. Record a big rectangle and a little rectangle, or a tall thin one and a short wide one.

Procedure

Sketch





Procedure

Sketch

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27. Start your rectangle somewhere new (not in the center of the screen).

Procedure

Sketch

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28. Try repeating your rectangles—by themselves, with combinations of two or more, or with turns or moves in between. Define a procedure for your favorite one.

Examples:

```
REPEAT 3 [RECTANGLE1]
REPEAT 3 [RECTANGLE1   RECTANGLE2]
REPEAT 5 [RECTANGLE1   FD 20]
```

Record your favorite variation, and sketch it.

Procedure

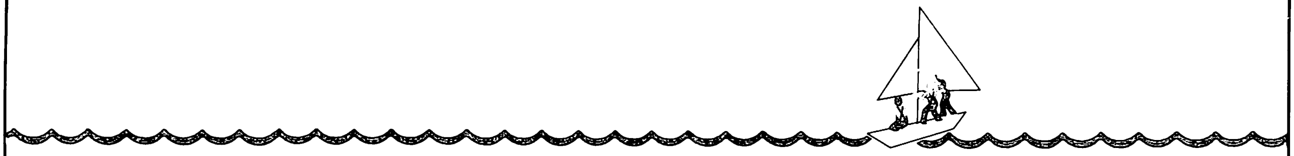
Sketch

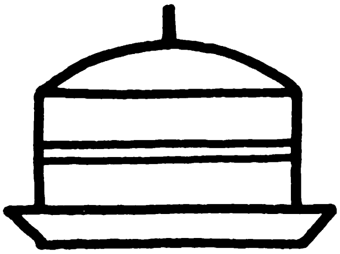
29. Can you stack three rectangles of different sizes on top of each other? Try it, and record how you did it.

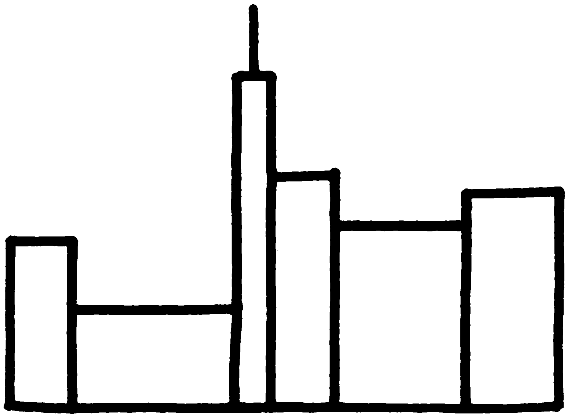
Procedure

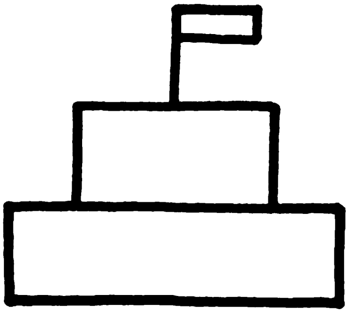
Sketch

Chapter Five



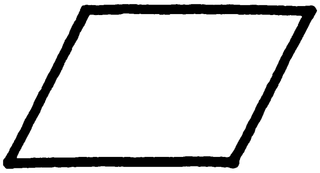


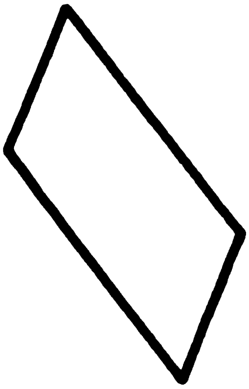


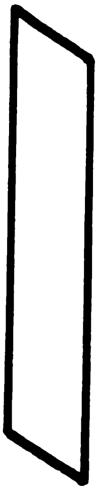


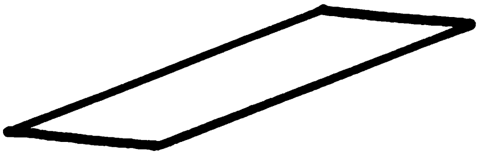
Parallelograms

Here are some parallelograms. Can you write a procedure to draw one of them?









Procedure

Sketch

As you can see from the sketches, parallelograms are four-sided figures with the pairs of opposite sides parallel. That means that if you extended the opposite lines, they would not cross each other. The opposite sides are also of equal lengths, just like rectangles, but the angles are not necessarily right angles. A rectangle is a special case of a parallelogram because its angles are 90°. The opposite angles of a parallelogram have to be equal, and, of course, the four angles have to add up to 360° (because of the Total Turtle Trip). In the activities below, see what else you can discover about parallelograms.

Look at the drawings at the end of the activities. Parallelograms are great for making drawings look 3-D (three-dimensional).

ACTIVITIES

30. Finish this parallelogram.

Procedure Sketch

```
TO PARGRAM
   FD 50
   RT 60
   ______________________
   ______________________
   ______________________
   ______________________
   ______________________
   ______________________
   ______________________
   ______________________
```

31. Make some more parallelograms with various angles. You may want to name them PARGRAM1, PARGRAM2, etc., or name them after the angle you use the most—PARGRAM60, PARGRAM30, etc.

Fill in the chart below to show the angles you use.

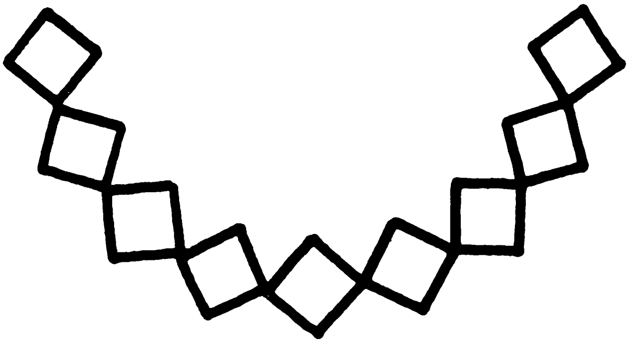
Name of Procedure	Angle 1	Angle 2	Angle 3	Angle 4

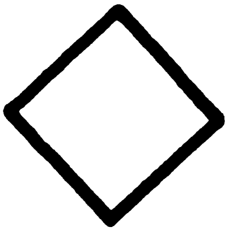
Did you discover a pattern? If so, what is it? ____________________

____

32. A rhombus is a special kind of parallelogram. All of its sides are the same length. Its angles do not have to be 90°. (A square is a special kind of rhombus.)

Define a procedure for a rhombus.





Procedure

Sketch

33. Experiment with repeating some of your parallelograms—by themselves, in combinations, or with turns or forward/back commands. Define your favorite, and record it here:

Procedure

Sketch

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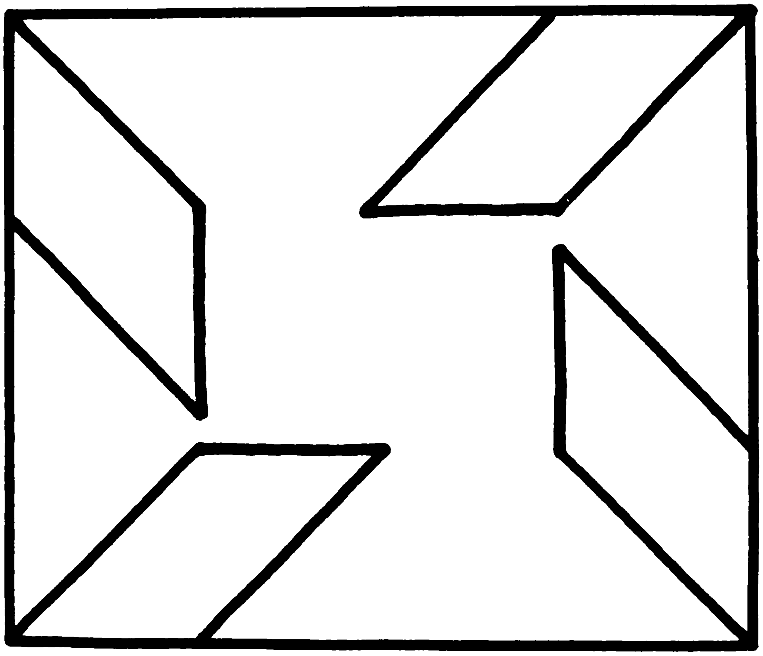
34. Here is the procedure for one parallelogram:

```
TO PARALGR
  RT 30
  FD 50
  RT 60
  FD 25
  RT 120
  FD 50
  RT 60
  FD 25
END
```

Can you figure out which of the procedures below made this design by using PARALGR?



```
PROCEDURE1     REPEAT 4 [PARALGR   BK 50]
PROCEDURE2     REPEAT 4 [PARALGR   BK 100]
PROCEDURE3     REPEAT 4 [PARALGR   FD 30]
PROCEDURE4     REPEAT 4 [FD 25   PARALGR]
```

Did you like any of the other designs better?

Challenger

35. Can you make a box that looks three-dimensional, using parallelograms and rectangles? Try it.

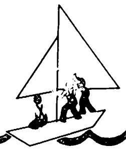
Procedure

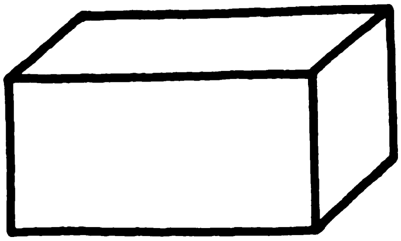
Sketch

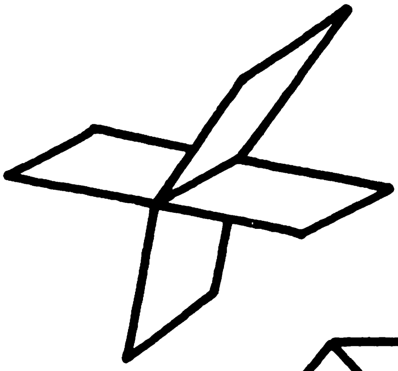
Chapter Five

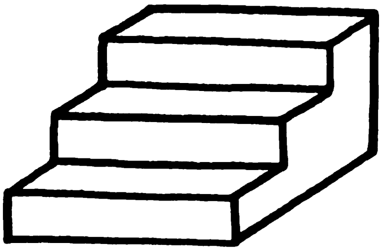
Procedures

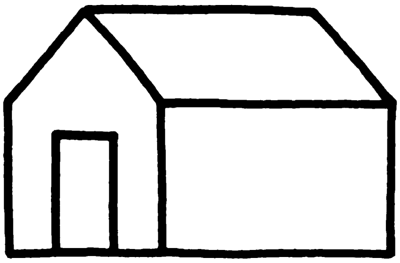
Sketch







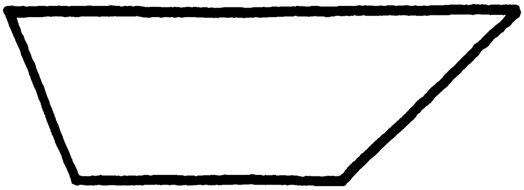


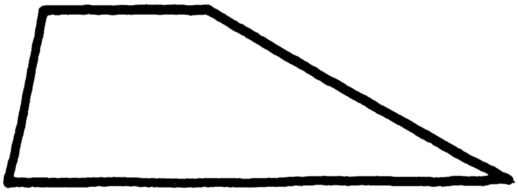


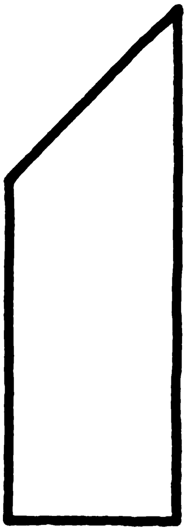
Chapter Five

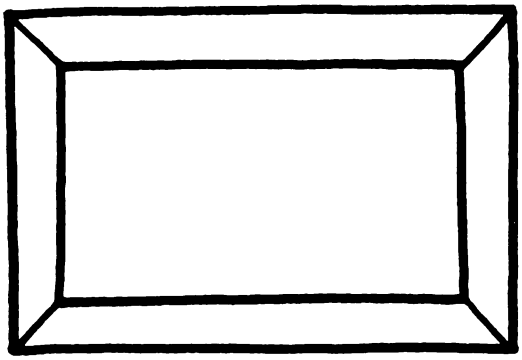
Trapezoids

Trapezoids are four-sided figures that have two parallel sides and two sides that are not parallel. See what you can figure out about the angles.









ACTIVITIES

36. Make some trapezoids. Remember that parallel lines will be heading in the same direction. PENUP may come in handy when you are checking to see if the angle is what you want.

Procedure

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Sketch

Procedure

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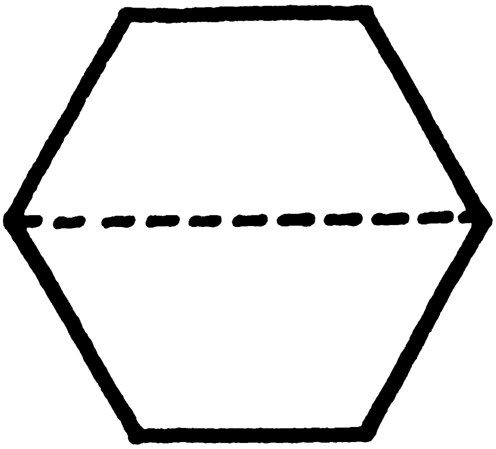
Sketch

37. A regular trapezoid is half of a regular hexagon. Write a procedure for a regular trapezoid.



Procedure

Sketch

38. Experiment with various combinations of trapezoids, rectangles, and parallelograms, using REPEAT, RT and LT, and FD and BK. Define your favorite, and record it here.

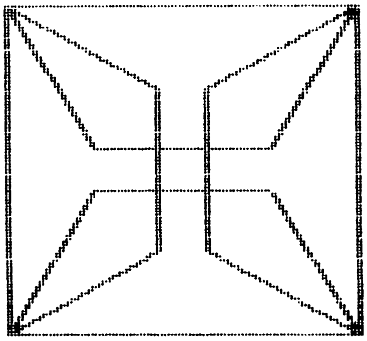
Procedure

Sketch

39. Here is the procedure for one kind of trapezoid:

```
TO TRAPEZ
   RT 30
   FD 25
   RT 60
   FD 25
   RT 60
   FD 25
   RT 120
   FD 50
END
```

Can you figure out which of the procedures below would produce this design?

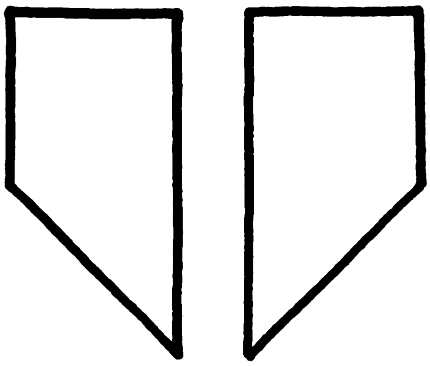


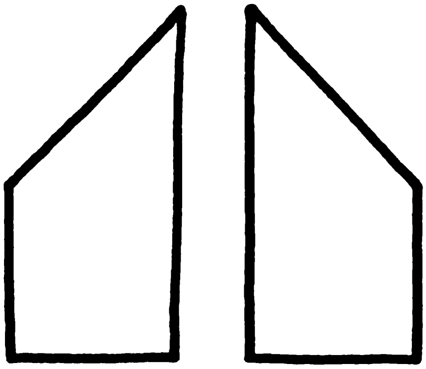
```
PROCEDURE1    REPEAT 4 [TRAPEZ   FD 25]
PROCEDURE2    REPEAT 2 [TRAPEZ   FD 20   TRAPEZ   BK 20]
PROCEDURE3    REPEAT 4 [TRAPEZ   BK 50]
PROCEDURE4    REPEAT 4 [TRAPEZ   RT 180   FD 50]
```

🔑 **40.** Can you make a right trapezoid (one with a right angle)? Can you make its mirror image?

Procedure

Sketch





Procedure

Sketch

Try to make a design using these two trapezoids, or experiment with mirror images of some of your other shapes.

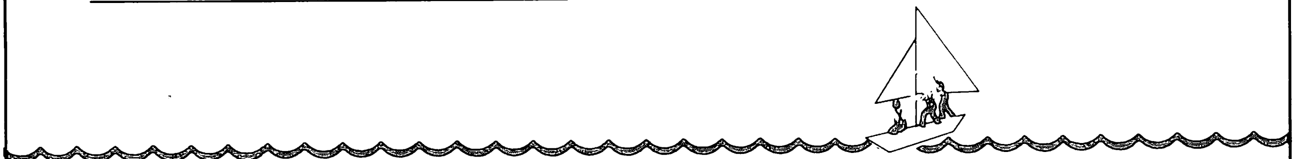
Procedure

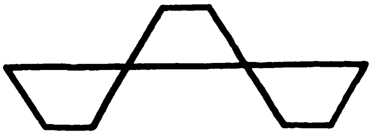
Sketch

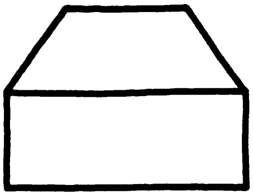
41. See if you can stack some trapezoids on top of each other or on top of rectangles or parallelograms. To make your shapes fit the way you want, you may have to alter the length of the sides.

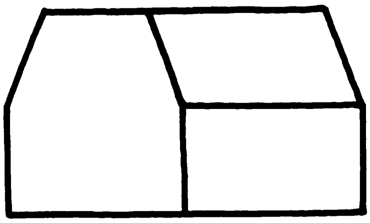
Procedure

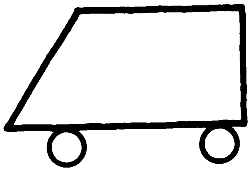
Sketch

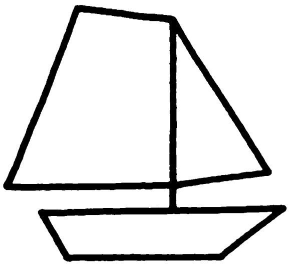






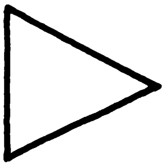


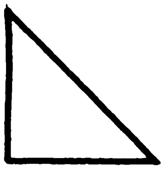


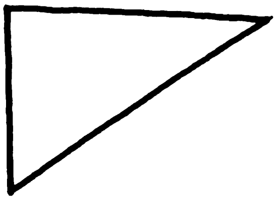


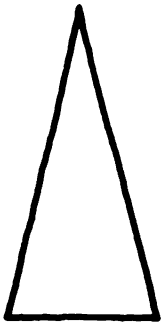
Chapter Five

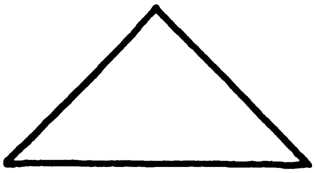
Triangles

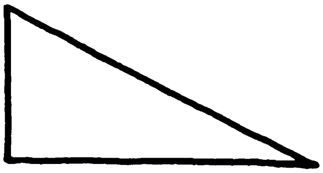












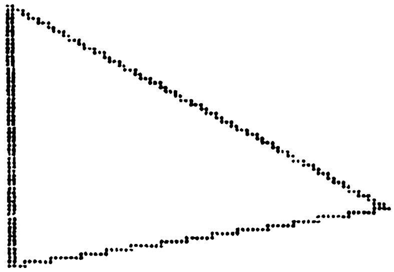
You've already made a regular (equilateral) triangle. Now try making triangles with various sides and angles. You may have trouble getting the third side of the triangle to join the first. Experiment, and don't worry if things don't come out perfect.

ACTIVITIES

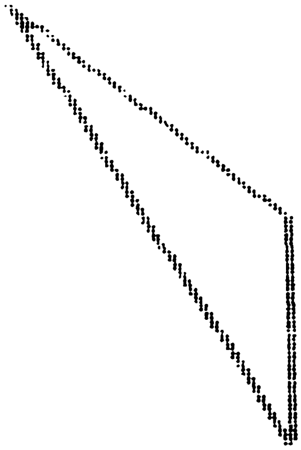
42. Can you find the missing angle and side for these triangles?
FD 56
RT 120
FD 85
RT 140

____

____



FD 48
LT 50
FD 70
LT 160
____
____



43. Make some of your own triangles, and record them here:

Procedure

____
____
____
____
____
____
____
____

Sketch

Procedure

____
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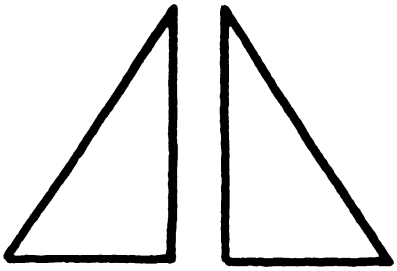
Sketch

44. Try to make a right triangle and its mirror image.

Procedure

Sketch



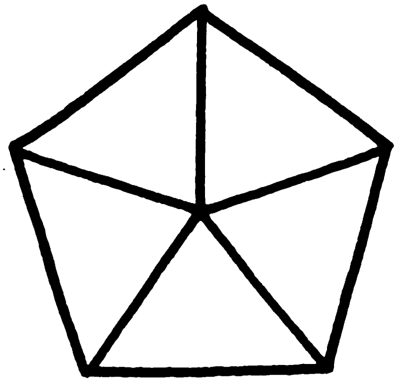
Procedure

Sketch

If you want, you could put these two right triangles together now in various ways to come up with a design.

45. Try to make the design shown here using this procedure for a triangle—or make up a triangle design of your own.

```
TO TRI72
  FD 50
  RT 126
  FD 60
  RT 126
  FD 50
  RT 108
END
```



Procedure

Sketch

Can you figure out why this triangle is called TRI72?

46. Create some interesting designs by mixing triangles with rectangles, trapezoids, circles, or parallelograms in any combinations you want. If you like, use colors. You may also like to put in some labels with PRINT statements or STAMPCHAR.

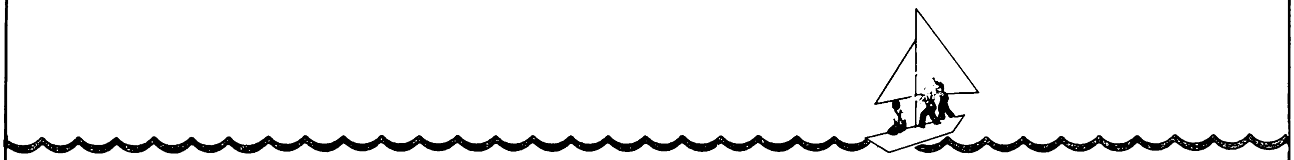
Procedure

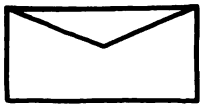
Sketch

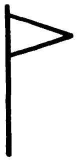
Procedure

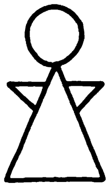
Sketch

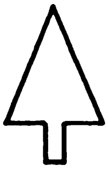
Chapter Five

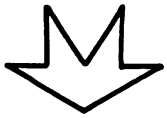


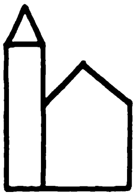


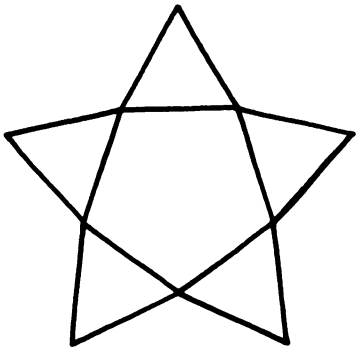


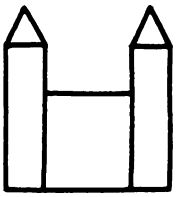






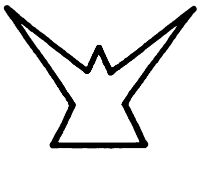


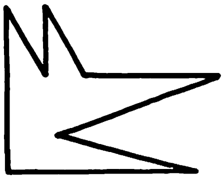


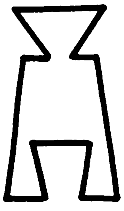


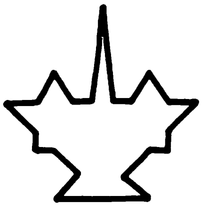
Miscellaneous

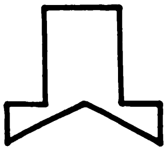
Make several miscellaneous shapes. They can be interesting by themselves, and they can be good materials for building designs.









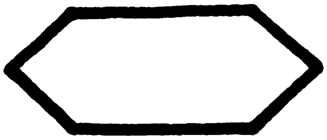


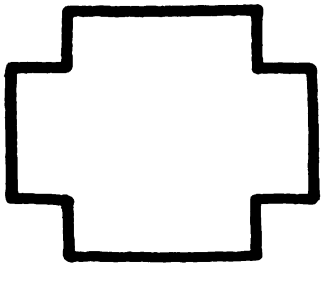
Chapter Five

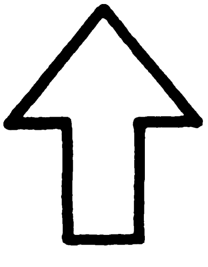
ACTIVITIES

Choose one or several or all of the types of shapes below. Define procedures for the ones you choose. Experiment to discover some interesting shapes.

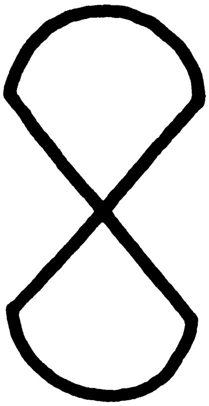
47. Irregular polygons. So far all the pentagons, hexagons, etc., you made have had all their angles equal and all their sides of the same length. Now try some oddly shaped polygons.

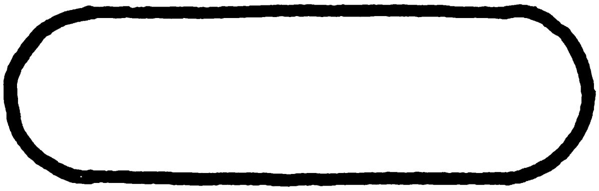






48. Other curved shapes, such as ovals or figure eights.





49. Combinations of curves and straight lines. There are millions of examples: cars, hats, airplanes, almost all everyday objects.

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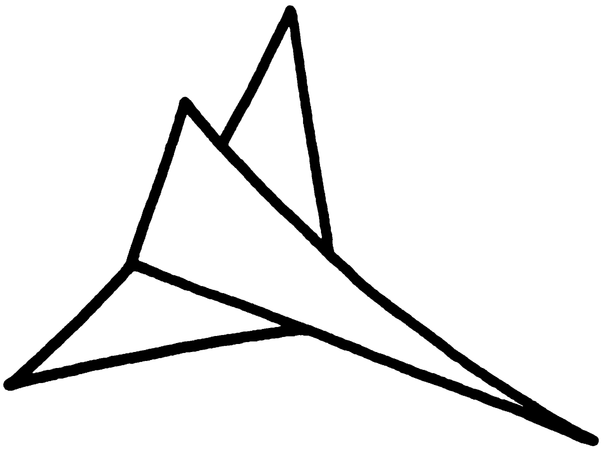
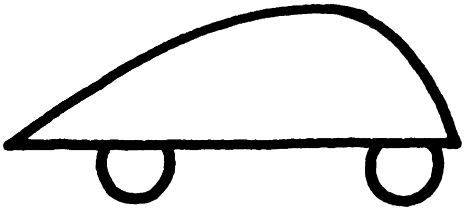
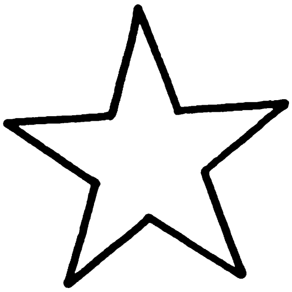
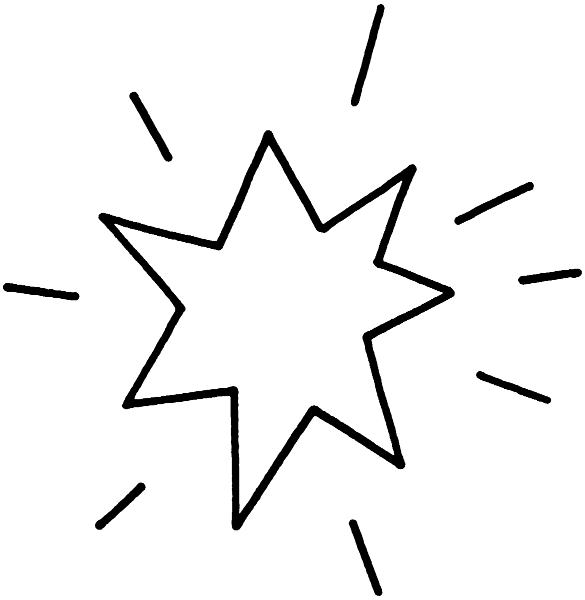
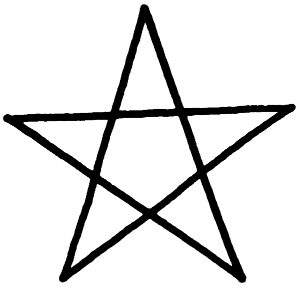




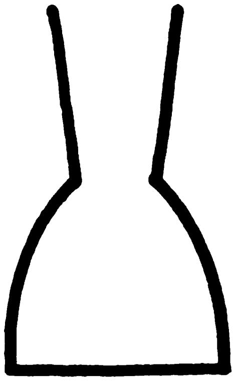
50. Stars. There are two main types of stars you can make. One type has inside lines, and the other doesn't. (See the pictures.) Stars can be regular, with equal sides and angles, or oddly shaped. You can make your stars appear to shine by adding extra lines around them like this:

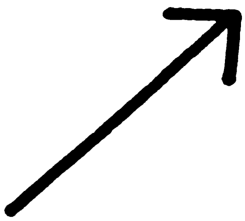


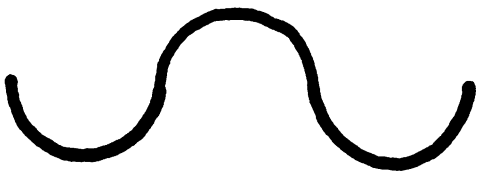




51. Open shapes.

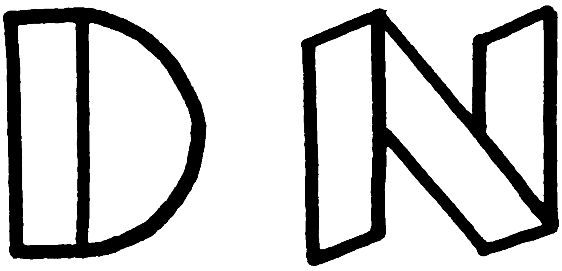




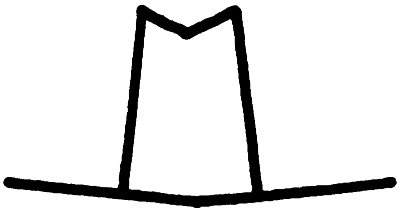


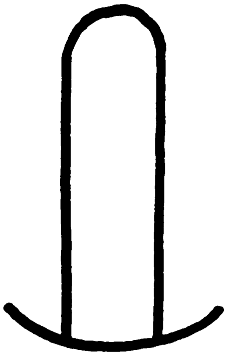
PROJECTS

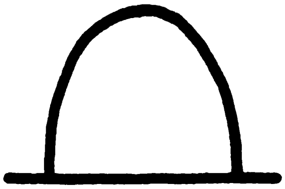
1. Make up fancy letters of the alphabet, such as these:

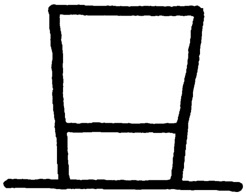


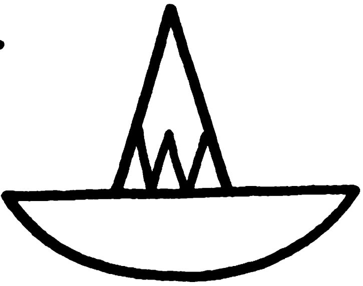
2. Make a series of hats: a dunce cap, witch's hat, baseball cap, bowler, Pilgrim hat, etc.

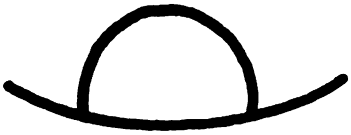


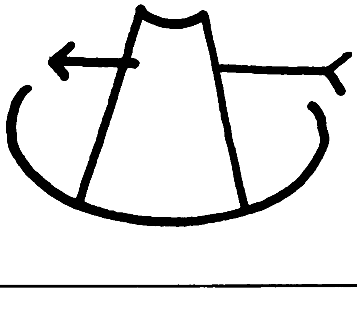










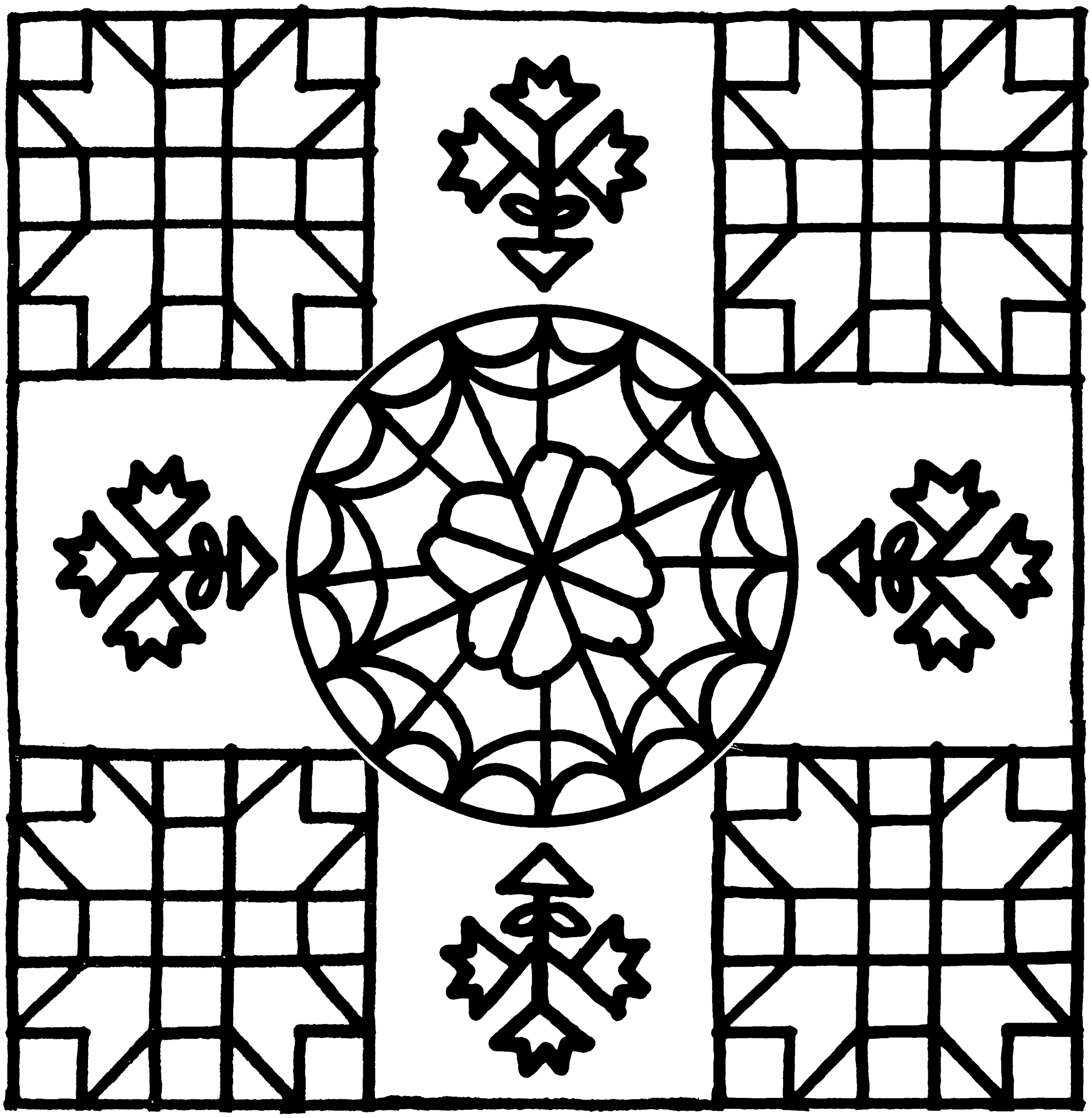


Note: Don't forget to save your shape procedures in a file on disk.

CHAPTER

SIX

Making Designs



Chapter Six

In this chapter, you will use the basic shapes you defined in Chapter Five to create all sorts of fancy designs. These designs would be almost impossible for you to draw on paper.

Designs are made by repeating shapes, and it is the turtle's ability to repeat a shape over and over that makes so many designs possible. You've already found, though, that if the turtle just walks over the same path again, nothing new happens. If your procedure for a shape leaves the turtle where it started, facing the same direction (a Total Turtle Trip), then repeating the shape won't get you anything new. For example, if you used our SQUARE procedure for making regular polygons in Chapter Five, and typed

```
REPEAT 10 [SQUARE]     <RETURN>
```

all that you would get would be one square. The turtle would walk around the square 10 times. To get a design by using the SQUARE procedure, you have to make the turtle move in some way before it repeats the square.

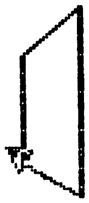
You may be wondering, ''What happens if I didn't use a Total Turtle Trip in creating a shape. I got the turtle back to its starting place, but not facing in the same direction. What difference does it make if the turtle ends up facing some other direction?''

That question is worth thinking about.

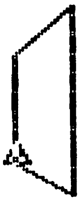
ACTIVITIES

1. Below are two procedures for a trapezoid. What is the difference between them?

```
TO TRAPEZ1
  FD 40
  RT 45
  FD 25
  RT 135
  FD 70
  RT 125
  FD 22
END
```



```
TO TRAPEZ2
  FD 40
  RT 45
  FD 25
  RT 135
  FD 70
  RT 125
  FD 22
  RT 55
END
```



The difference may look minor, but in fact it is not. In both procedures, the turtle ends up at its starting place but pointed in different directions. In TRAPEZ1 the turtle has turned a total of 270°; in TRAPEZ2, 360°. TRAPEZ2 uses a Total Turtle Trip. TRAPEZ1 doesn't.

To see the effect of the last command in TRAPEZ2, type in both of these procedures. (If you already have a trapezoid with one of these names, then pick a new name for TRAPEZ1 or TRAPEZ2.)

Now fill in the chart below by repeating each command until the turtle will only trace over a previous trapezoid. First guess how many repeats will be needed, and then see at the computer if you were right. For example, you might type

```
REPEAT 3 [TRAPEZ2   RT 30]
```

		Repeats				Repeats	
Procedure		Guess	Actual	Procedure		Guess	Actual
TRAPEZ1	RT 30	_____	_____	TRAPEZ2	RT 30	_____	_____
TRAPEZ1	RT 45	_____	_____	TRAPEZ2	RT 45	_____	_____
TRAPEZ1	RT 60	_____	_____	TRAPEZ2	RT 60	_____	_____
TRAPEZ1	RT 90	_____	_____	TRAPEZ2	RT 90	_____	_____

Which procedure seems easier to work with?

____

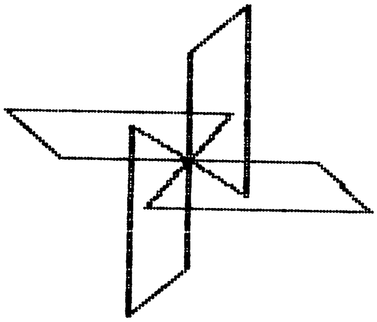
You can draw shapes and leave the turtle wherever you want; but when you use a shape in a design, you'll want to know exactly where the turtle is. You'll have more control if you give the turtle a Total Turtle Trip (TTT).

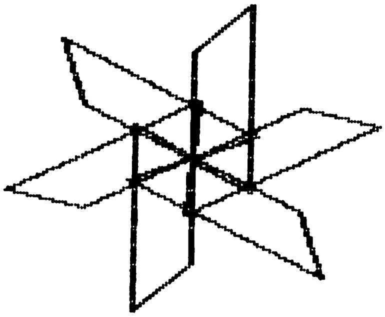
Chapter Six

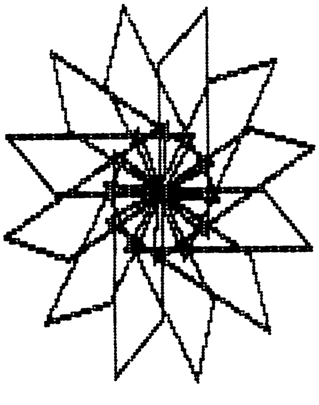
Spinning Designs

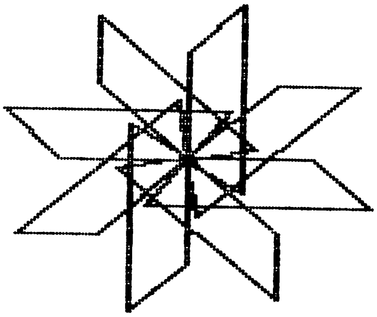
Let's say we have a shape with a TTT, and we want to make a design out of it. We have to make the turtle move in some way before it repeats the shape. Otherwise, we won't get anything new. One easy way to move the turtle is with a RIGHT or LEFT command. That's the method we'll use in this section. We call the results *spinning designs* because the design looks like it's made out of a shape spinning around.

To make spinning designs, it is easiest to start with TTT shapes. The regular polygons that you defined in Chapter Five all used the TTT. Some of your shapes from Chapter Five, such as trapezoids and odd shapes, may not have used the TTT. You may have to edit some of your procedures and add one last turn to make the turtle's turns add up to 360°.



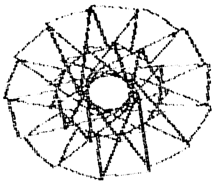


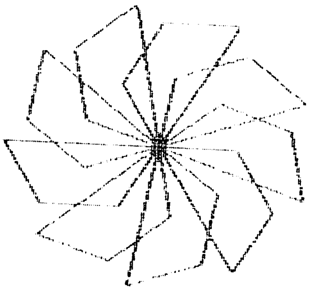


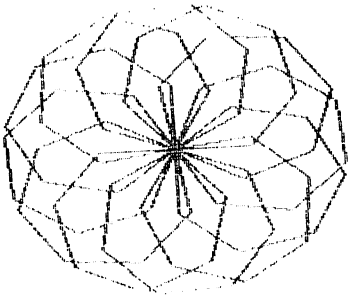


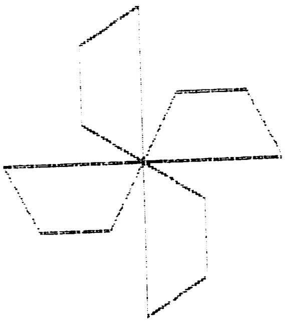
Chapter Six

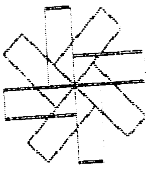
See if you can make one of these designs or one like them.











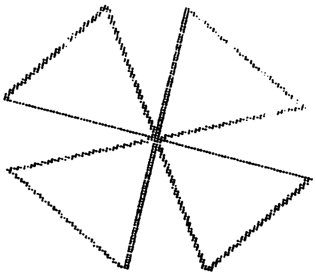
Let's see what's going on in a spinning design. We'll start with a simple equilateral triangle and try to make a design by rotating the turtle 60° in between its repeats.
Here's the triangle procedure:

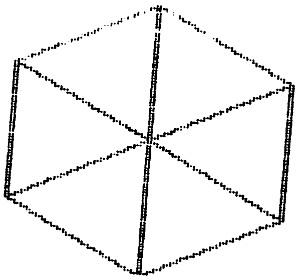
```
TO TRI
  REPEAT 3 [FD 50   RT 120]
END
```

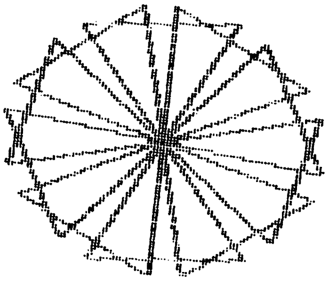
Now if we repeat TRI RT 60, we should get a design. Try it out. How many times do you have to repeat before the turtle goes over an old path? ______________
(You could make a design with fewer repeats, but we're interested here in designs that spin a shape all the way around.)

Change RT 60 to RT 90. Now how many repeats do you need? ______________
What does the number of repeats depend on? ______________________________

____







Experiment some more with changing the angle. Can you discover a general rule for how many times to repeat for a given angle? Is it familiar to you?____________

Example: We can try the same thing with a more complicated shape, such as our ZT design from Chapter Four. Jenny and Walter made this design:

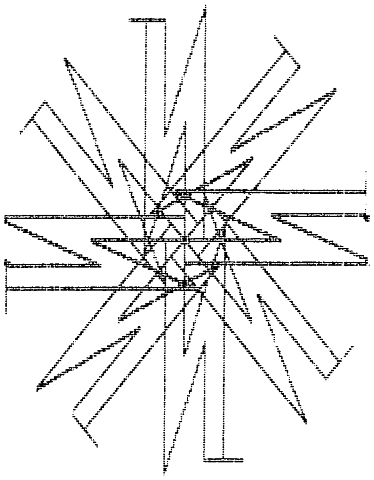
```
TO WINDMILL
  REPEAT 8 [ZT.DESIGN   RT 45]
END
```

They happened to choose RT 45 for the turn; they could have picked other angles. They also could have used LT instead of RT. You could try changing the angle and using LT to see if you can come up with a design you like better than Jenny and Walter's WINDMILL

```
TO WINDMILL
  REPEAT 8 [Z   T   Z   T   LT 45]
END

TO Z
  RT 90
  FD 50
  LT 160
  FD 60
  RT 160
  FD 50
END

TO T
  FD 50
  LT 90
  FD 10
  RT 180
  FD 20
END
```



Chapter Six

ACTIVITIES

Use the shapes from Chapter Five to try these spinning designs. Make sure each shape uses the TTT. You may have to add one LT or RT command at the end of the procedure to get the turtle to complete a 360° turn.

2. Can you figure out how many repeats are needed to get back to the beginning?

a. REPEAT __________ [{hexagon} RT 30] (This is a beauty!)

b. REPEAT __________ [{rectangle} RT 60]

3. Can you figure out what angle the turn is, given the number of repeats?

a. REPEAT 8 [{square} RT __________]

b. REPEAT 12 [{right trapezoid} LT __________]

4. This is a basic shape called PETAL. Type in the PETAL procedure and the super-procedure, FLOWER.

```
TO PETAL
  REPEAT 6 [RT 15   FD 10]
  RT 90
  REPEAT 6 [RT 15   FD 10]
  RT 90
END
```

```
TO FLOWER
  REPEAT 4 [PETAL   RT 90]
END
```

Can you make another FLOWER super-procedure that has twice as many petals?

Procedure

____

____

____

____

Sketch

Can you make a FLOWER that has three times as many petals?

Procedure

____

____

____

____

Sketch

Design your own flowers by changing the PETAL procedure in some way—and rename it. This is a good place to add color if you can.

5. Take one of the shapes from Chapter Five, such as the parallelogram or the trapezoid, and make some pinwheel shapes with varying numbers of blades. Remember to make sure the initial shape uses the TTT.

Procedure

Sketch

Challenger

6. Make a spinning design with a letter. Can you get the turtle back to 0° at the end of the letter? Can you get it back to the starting point of the letter? Try a spinning design both ways. What is the difference?

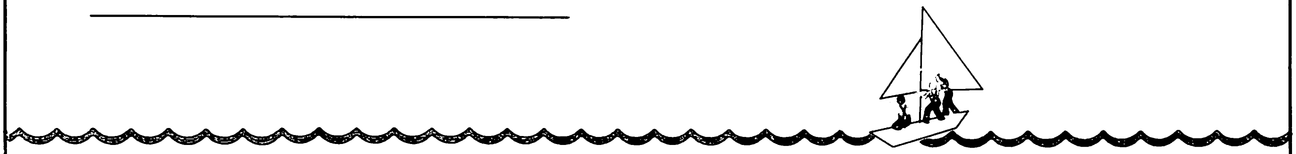
Procedure

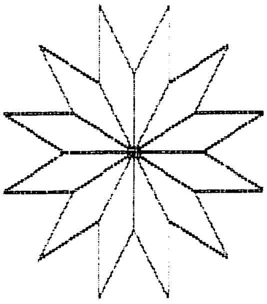
Sketch

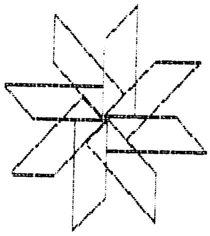
Chapter Six

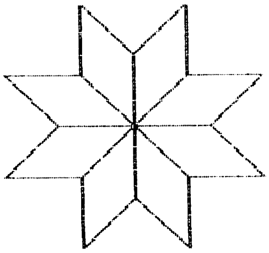
Procedure

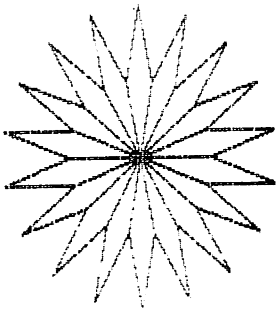
Sketch

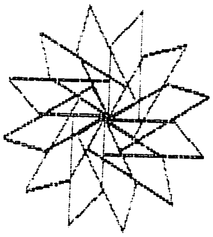








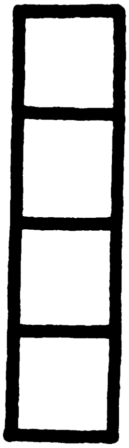




Stacking Designs

A second way to create designs is simply to move the turtle forward or back between each repeating of a shape. A simple example would be to have the turtle make a square, walk over one side of the square, and then make the next square. The result would be a stack of squares like this:

```
TO SQ.STACK
  REPEAT 8 [SQUARE   FD 50]
END
```



(where the SQUARE procedure makes a square with sides of 50).

A stack of hexagons is a little more interesting. If you start with this HEXAGON procedure,

```
TO HEXAGON
  REPEAT 6 [FD 30   LT 60]
END
```

what would HEX.STACK (like SQ.STACK) look like?

ACTIVITIES

In this set of activities, you will find a lot to explore. You can try going forward varying amounts, so that the shapes overlap, just touch, or have spaces in between. You can also change the number of times you repeat the shape. And, of course, you can try making stacks with lots of the shapes you created yourself in Chapter Five.

🔑 **7.** Make a stack of octagons. Continue the stack until it appears to come up from the bottom of the screen. Type

```
<f5>
```

to see the full screen drawing.

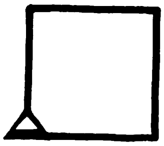
Change the amount the turtle goes forward between repeats until you get a stack you really like. Record it here. The sketch will be hard to make; don't worry about getting it perfect. Just draw something that will remind you of the turtle's screen drawing.

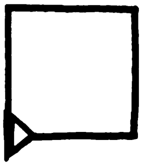
8. Try making a row of a certain shape instead of a stack. You can try a couple of ways. One way is to rotate the turtle *before* you make a stack.

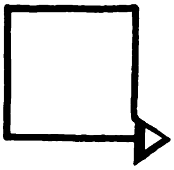
A second way is to move the turtle over to the right or the left in between its drawings of the shape. Since a RIGHT or LEFT turn only rotates the turtle, you will have to put in a RIGHT or LEFT command *and* a FORWARD or BACK command.

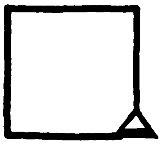
Example: To get a row of squares,

```
TO SQ.ROW
  REPEAT 8 [SQUARE   RT 90   FD 50   LT 90]
END
```









9. Make a stack going off at an angle. Use a new shape for this one (such as a rhombus or rectangle).

____

____

____

____

10. Here is a procedure for an irregular trapezoid. Try to make a stack, using this shape.

```
TO TRAP4
  FD 40
  RT 40
  FD 30
  RT 60
  FD 30
  RT 120
  FD 76
  RT 140
END
```

Procedure	Sketch
______________________________	
______________________________	
______________________________	
______________________________	

11. Choose another shape, and make a stack starting in the lower-right-hand corner of the screen.

Procedure	Sketch
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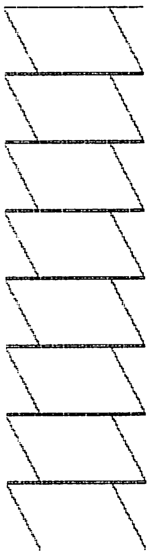
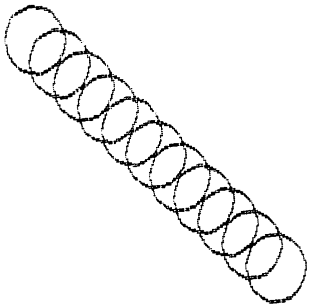
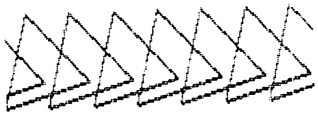
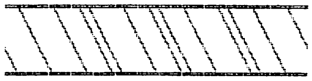
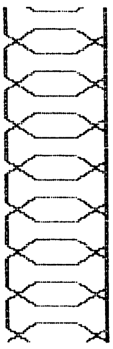
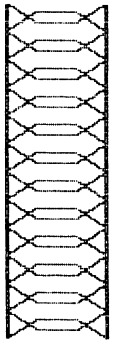


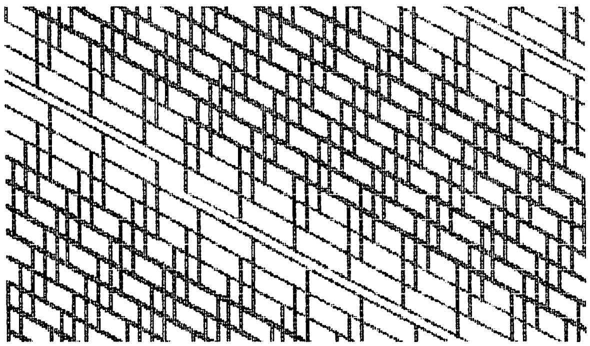










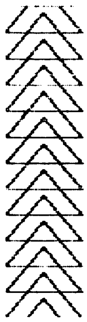


Move Procedures

Jason and Stacey made a stack of triangles and then decided that they wanted to make more stacks going across the screen.

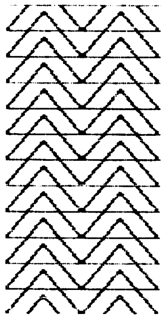
```
TO STACK
  REPEAT 13 [TRI   PU   FD 20   PD]
END

TO TRI
  RT 30
  REPEAT 3 [FD 40   RT 120]
  LT 30
END
```



They wanted the stacks to be just touching, with no overlaps and no spaces in between. They knew that they had to move the turtle over after it finished drawing one stack. They figured out that these commands would move the turtle over exactly the right amount:

```
PU
RT 90
FD 40
LT 90
PD
```



So to get a series of stacks, they had to type STACK and then the above five commands for moving the turtle. Stacey and Jason got tired of typing so many commands. A good shortcut was to define a move procedure, like this:

```
TO MOVE
  PU
  RT 90
  FD 40
  LT 90
  PD
END
```

Now all they had to type was

```
REPEAT 8 [STACK  MOVE]
```

That worked just the way they wanted.

ACTIVITIES

12. Take the octagon stack you made in the last section, and invent a move procedure that will put a stack next to your first one. You may want to overlap the stacks or make them just touching. Experiment to find a move procedure that makes a design you really like. When you are done, define a procedure that creates a design of many rows of octagon stacks.

Procedure Sketch

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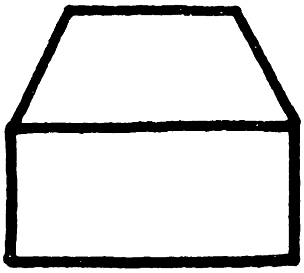
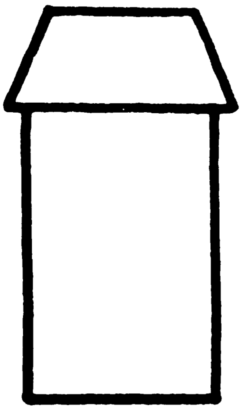
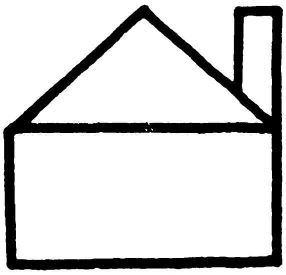
13. You don't have to stick to geometric shapes for your rows. You can use pictures such as these houses:







See if you can figure out procedures to make a house and then to make a row of houses. Here's an outline for you:

```
TO ROW.HOUSES
  REPEAT ____ [HOUSE   MOVE.HOUSE]
END

TO HOUSE
  FRAME
  ROOF
END

TO MOVE.HOUSE

  ______________________________

  ______________________________

  ______________________________

  ______________________________

  ______________________________

  ______________________________

  ______________________________
END
```

TO FRAME

____

____

____

____

____

____

____

END

TO ROOF

____

____

____

END

14. Make a row of rectangles across the screen.

____

____

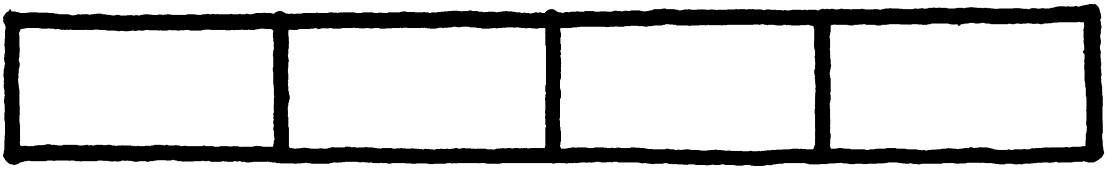
____

____

____

____

____



Can you invent a move procedure to stack the rows on top of each other?

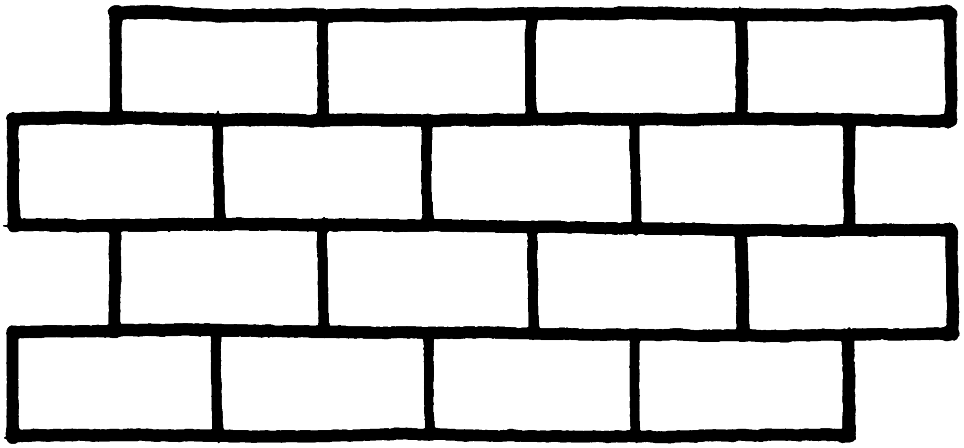
Procedure

Sketch

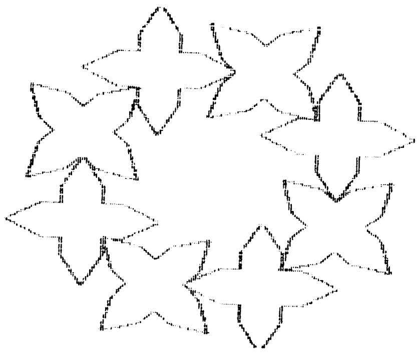
Can you stack the bricks so that the each row of bricks is shifted over the row below it by half a brick—like real bricks?

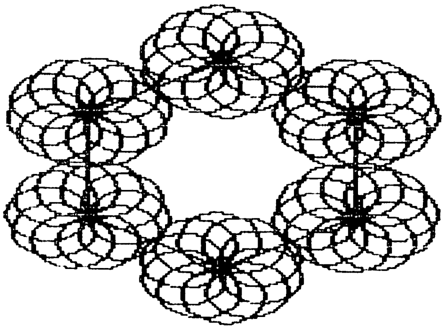
Procedure

Sketch



15. Your move procedure doesn't have to move straight up or down, right or left. You can use various turns in your move procedure to create interesting designs. Here are two examples:

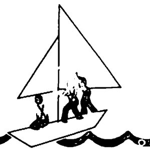


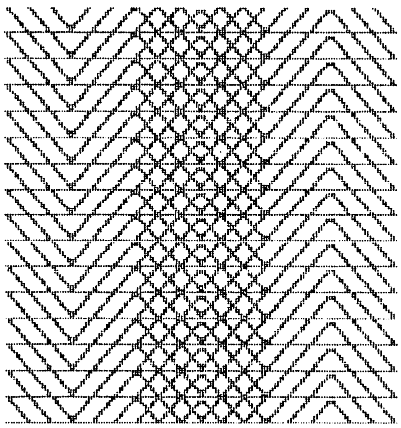


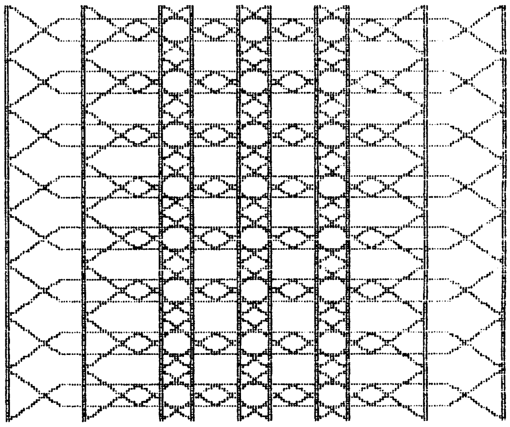
Try writing the procedure for a similar design.

Procedure

Sketch







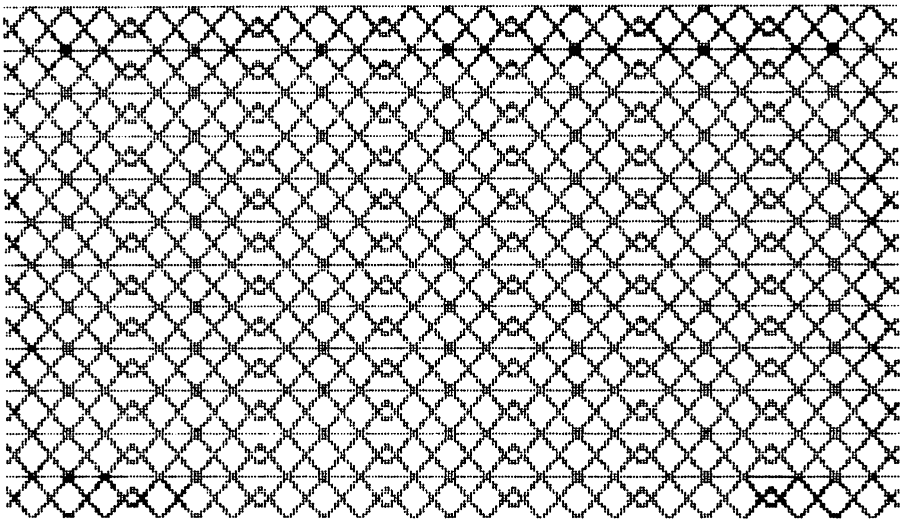
Chapter Six

Writing a Program

A Group of Procedures Working Together

While Jason and Stacey were experimenting with their stacks, they got the turtle upside down by mistake. They found that they got a beautiful lacy pattern when the turtle made an upside-down stack on top of a rightside-up one. Often your mistakes lead to more interesting designs than the ones you set off to make.

Stacey and Jason experimented some more until they had the lacy design they liked best. They called their design LACE. By now they had a whole string of procedures. Each new procedure used an earlier one as one of its commands. Here is the full list:



```
TO LACE
  REPEAT 8 [STACK   MOVE]
  RT 180
  REPEAT 8 [STACK   MOVE]
END

TO STACK
  REPEAT 13 [TRI   PU   FD 20   PD]
END
```

```
TO MOVE
  PU
  RT 90
  FD 40
  LT 90
  PD
END

TO TRI
  RT 30
  REPEAT 3 [FD 40   RT 120]
  LT 30
END
```

The procedure called LACE is the *mainline* procedure. When you want to see the design, all you do is type

```
LACE
```

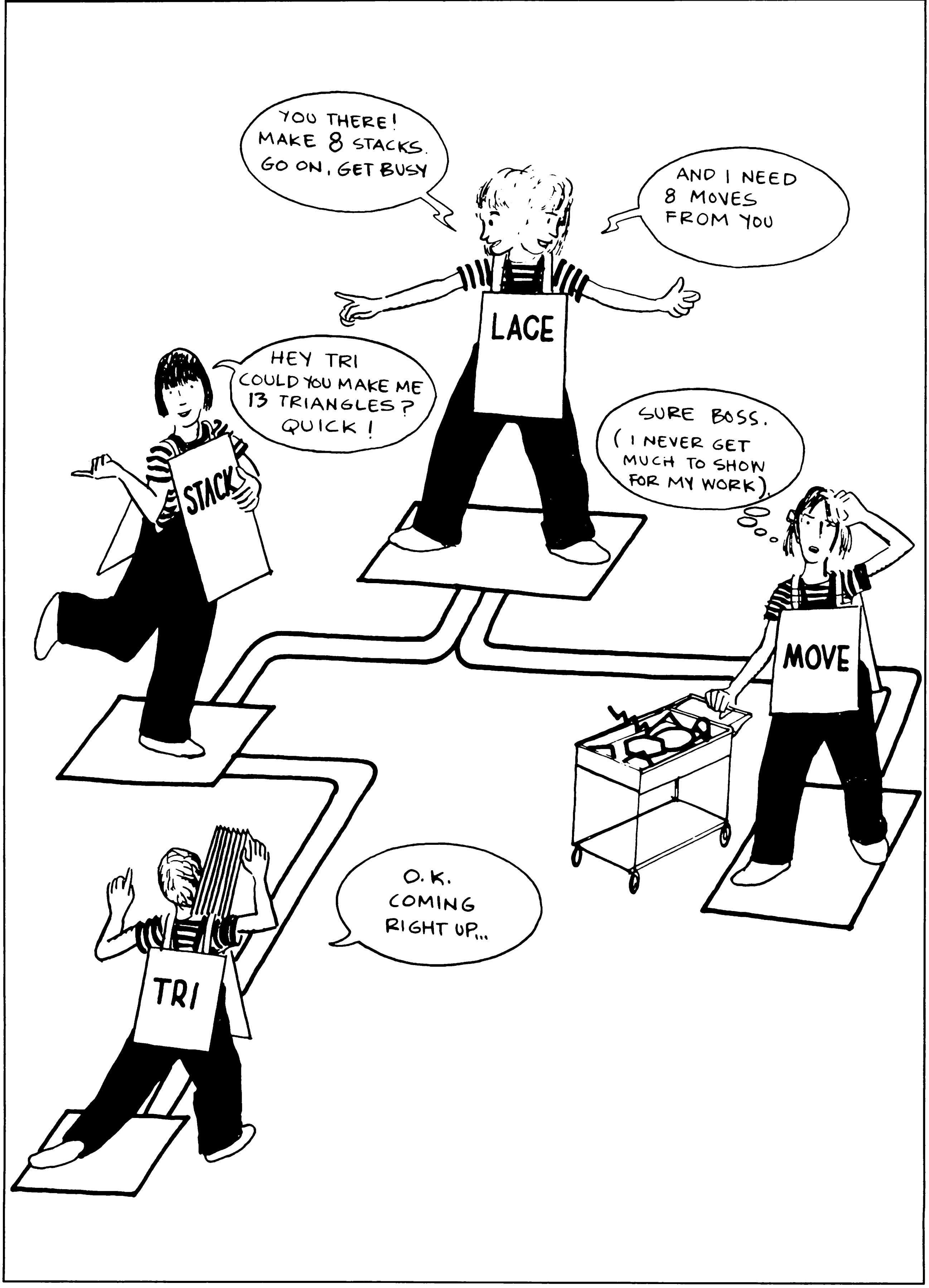
The LACE procedure is like the president of a big company. It is the one in charge. In a big company, the president calls on vice-presidents or other workers to take over certain jobs. In the same way, a mainline procedure such as LACE calls on other procedures (STACK and MOVE) to do the work. (STACK in turn calls on TRI to do its work.)

STACK, MOVE, and TRI are called *sub-procedures* because they are called by the mainline procedure, LACE. TRI is a sub-procedure of the sub-procedure STACK.

TRI and STACK can stand by themselves to make a drawing, even though they are sub-procedures. They are like vice-presidents. MOVE really doesn't do much by itself. It just has a special job to do for LACE. MOVE is like an ordinary worker.

The group of procedures in LACE is called a *program*. Even though the lacy design is complicated, the program for making it is made up only of simple, short procedures. A well-written program—even a big, complicated one—will be made up of lots of short, simple procedures, just as the LACE program is.

Chapter Six


YOU THERE! MAKE 8 STACKS. GO ON, GET BUSY
AND I NEED 8 MOVES FROM YOU
LACE
HEY TRI COULD YOU MAKE ME 13 TRIANGLES? QUICK!
STACK
SURE BOSS. (I NEVER GET MUCH TO SHOW FOR MY WORK).
MOVE
O.K. COMING RIGHT UP...
TRI

Using More Than One Move Procedure

Sometimes you will need more than one move procedure to make a fancy design. For example, when you wanted to draw bricks in Chapter Six, you needed one move procedure to make a row of rectangles, and a second move procedure to pile rows on top of each other.

You can name your move procedures to describe what they do, for example, MOVE.RIGHT and MOVE.UP.

Move Procedures at the Beginning of a Design

Another time you will want a move procedure is to start your design somewhere besides the center of the screen. You can give such a procedure a name such as SETUP or START. You can also set up the screen and turtle the way you want them for the design. Here's an example:

```
TO START
  DRAW
  FULLSCREEN
  HT
  PC 3
  PU
  LT 90
  FD 140
  RT 90
  PD
END
```

(**Note:** FULLSCREEN can be used as a command inside a procedure.)

This START procedure gets everything ready for the main work of the program. It sets up the full screen for drawing, hides the turtle, sets the pen color to green, moves the turtle to the left edge of the screen, and heads the turtle up again.

ACTIVITIES

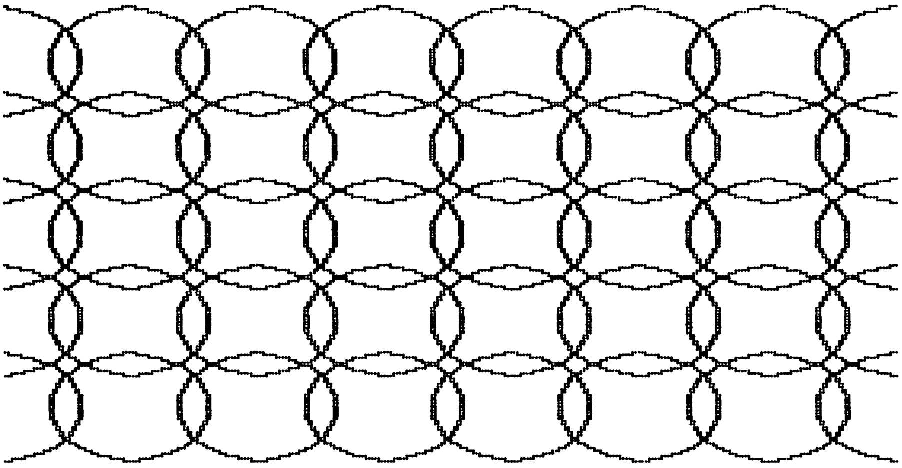
For these activities, we provide outlines for your programs. You may want to use scratch paper before you write here. You probably won't fill in each outline in the order it appears. For example, you will usually write the procedure for your shapes first.

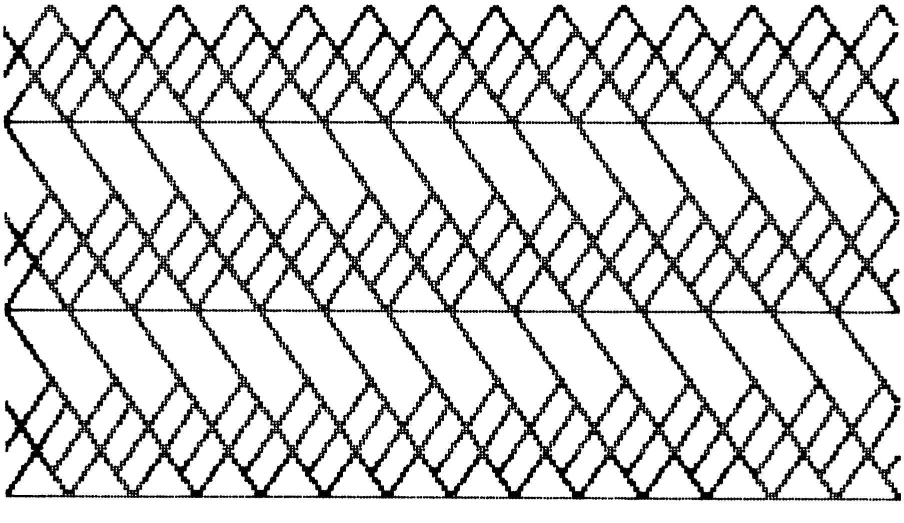
🔑 **16.** Using all you have learned so far, see if you can fill the screen by repeating one shape. Start with your shape and fill in this outline from the bottom up.

```
TO ________________________                        (mainline procedure)

  REPEAT _____  [ ______________________  ______________________ ]
                      (row of shapes)         (Move row up.)
END

TO ________________________                           (row of shapes)

  REPEAT _____  [ ______________________  ______________________ ]
                         (shape)              (Move shape.)
END

TO ________________________                           (Move row up.)
  ___________________________________
  ___________________________________
  ___________________________________
END

TO ________________________                                  (shape)
  ___________________________________
  ___________________________________
  ___________________________________
END

TO ________________________                             (Move shape.)
  ___________________________________
  ___________________________________
  ___________________________________
END
```

17. Try to fill the screen exactly with any one shape—such as a triangle—so that there is no wrap-around. The screen is 320 turtle steps wide and 260 up and down. Remember, you can make the computer do the calculations to figure out how many of each shape will fit across the screen.

These are the procedures you will need:
Mainline
Row of shapes
Move procedures
Basic shape





PROJECT

1. You have probably seen some fancy designs on the edges of rugs, clothing, picture frames, or writing papers. These designs are called borders. You can make some great-looking borders by drawing rows along the edges of the screen. If you want, you can even put a picture in the center with a border around it.
Sketch of Basic Shape:

Sketch of Border:

You will need:

Mainline procedure
Start procedure
One edge of border
Basic shape
Move procedures

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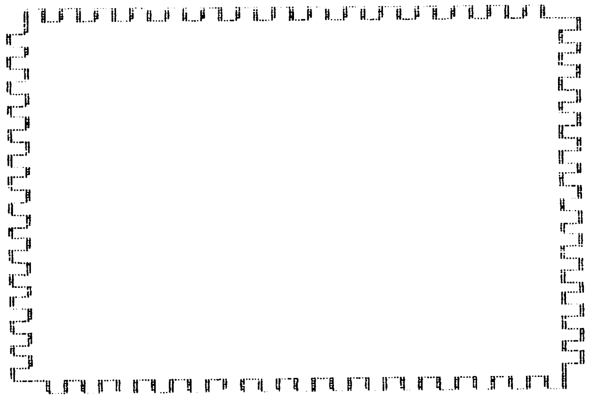
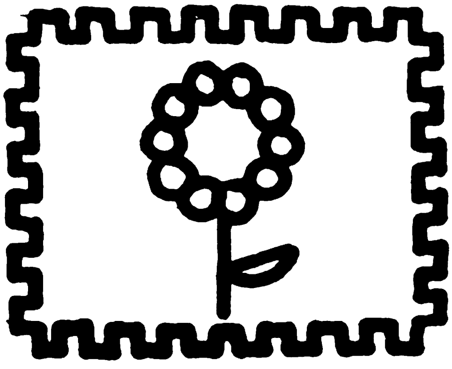
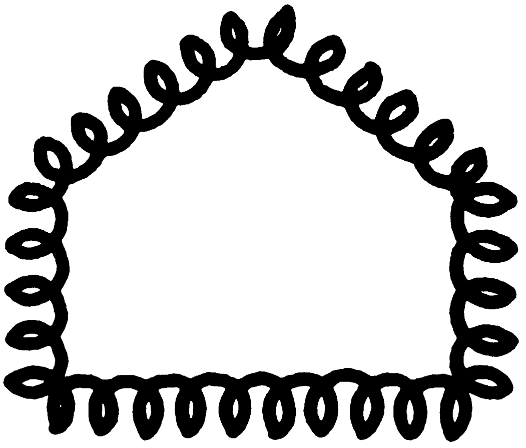


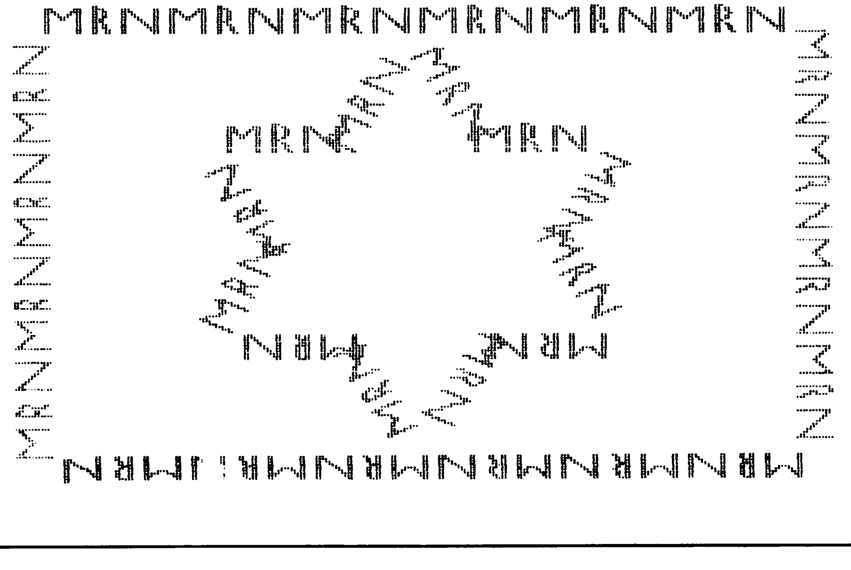
2. You can use borders for many more projects. You can make borders for any of your favorite designs.



Your borders don't have to be rectangular; try some other shapes such as this:



You can even use the basic pattern of your border to make designs such as this:

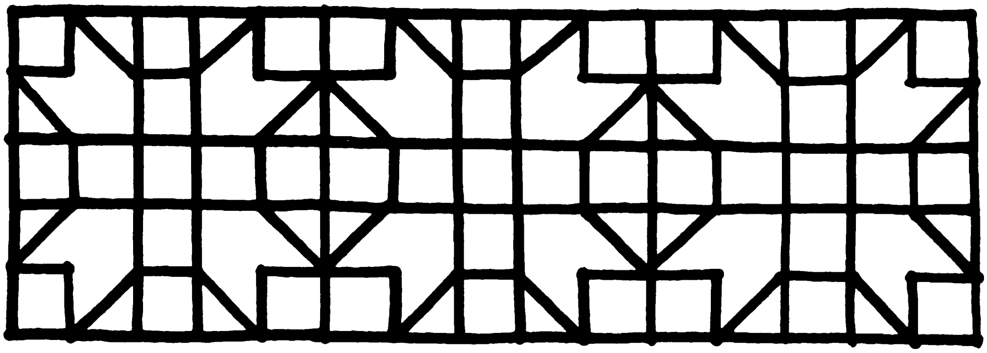


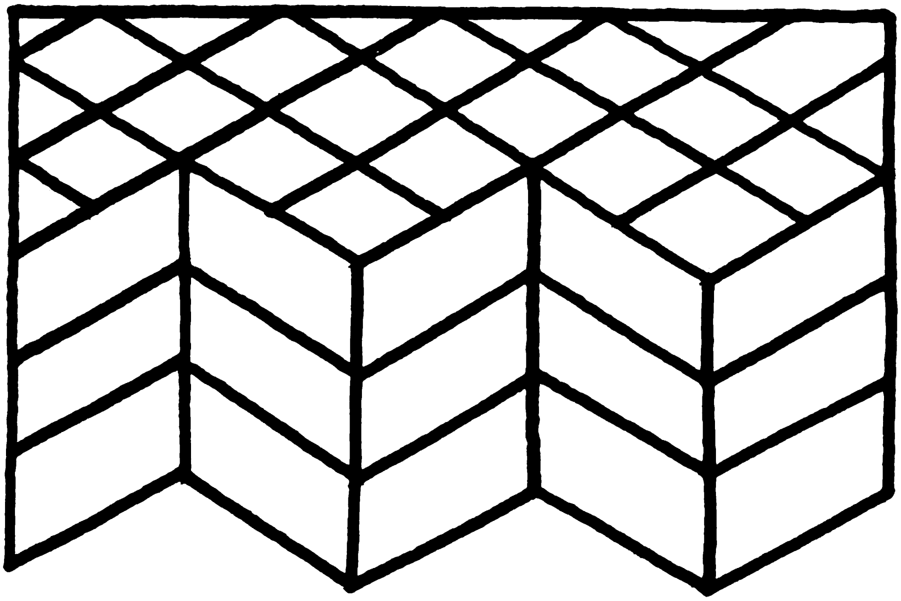
Chapter Six

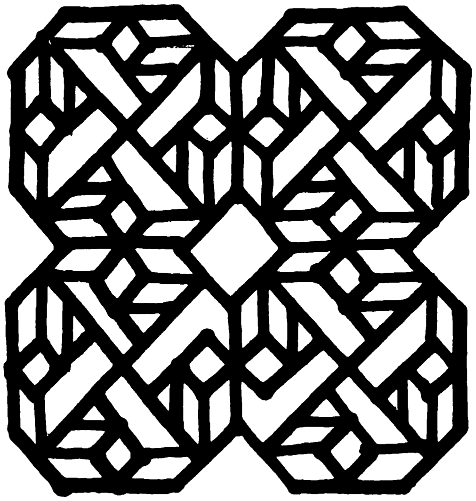
Combining Shapes

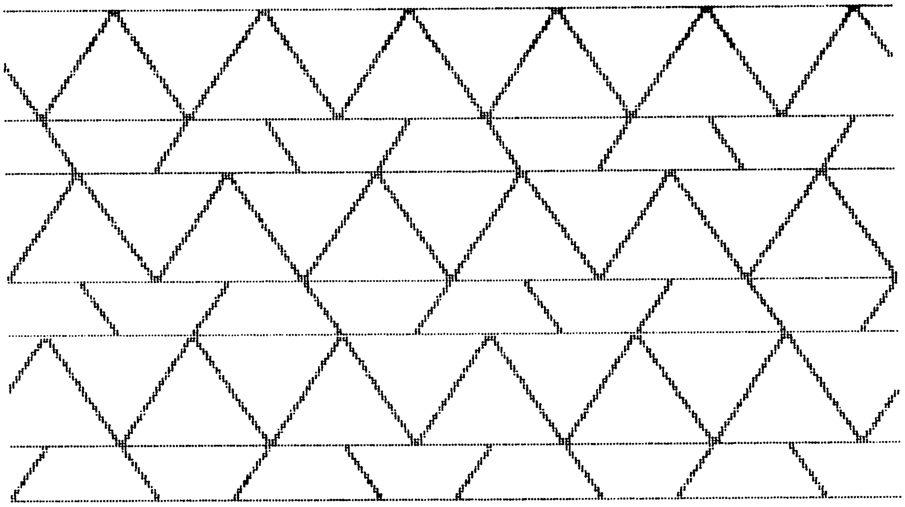
Ready for even more possibilities? So far, all of our designs have been made out of a single shape. Now that you know how to put a mainline procedure and a group of other procedures together into a program, you can make even fancier designs by using more than one shape.

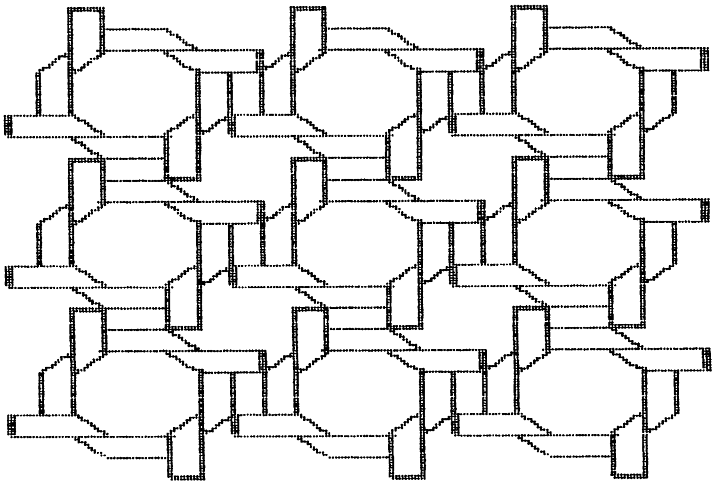
Inspiration for designs can come from many places: patchwork quilts, floor tiling patterns, nature, and everyday objects. Some designs, such as patchwork quilts and floor tilings, put different shapes next to each other. No space is left over between the shapes. These designs are called tilings.



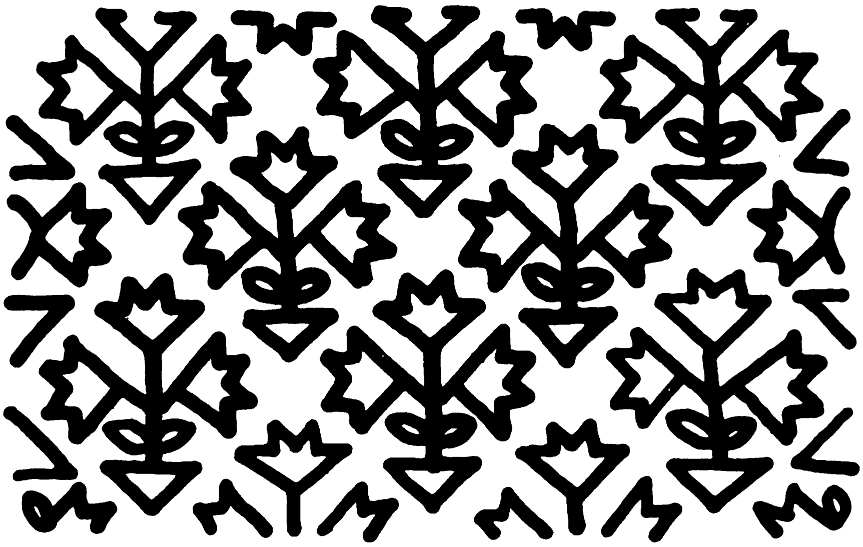




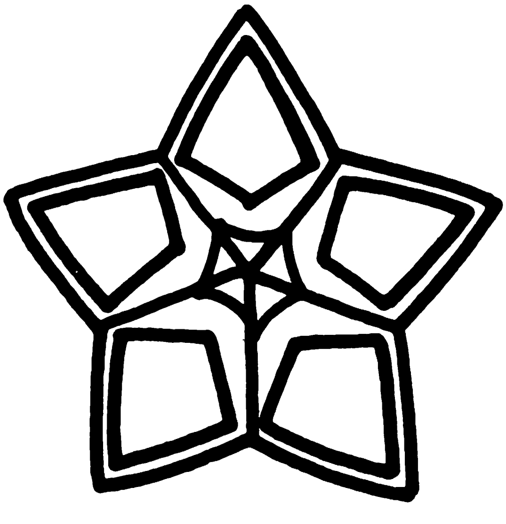


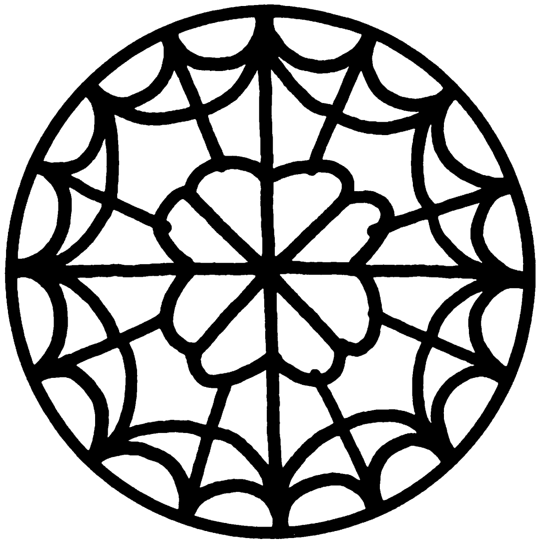


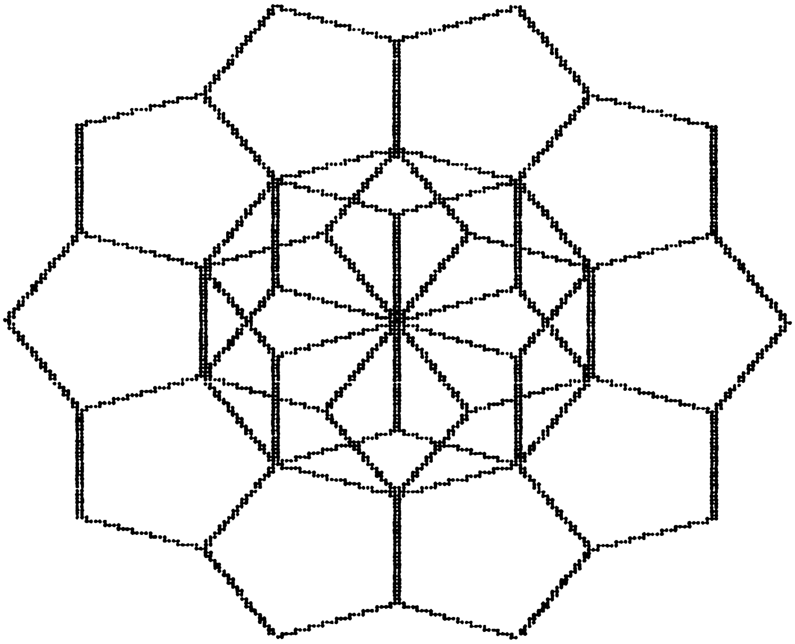
In other designs, shapes overlap or have spaces between them.

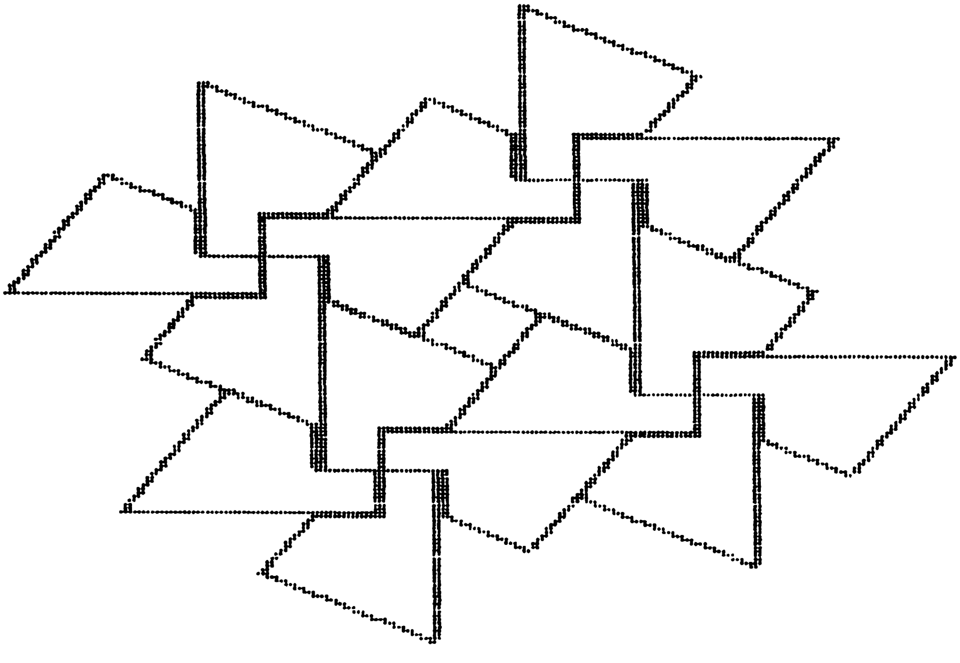


A third kind of design starts with some shapes in the center and builds outward.

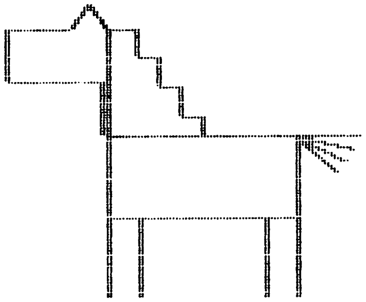


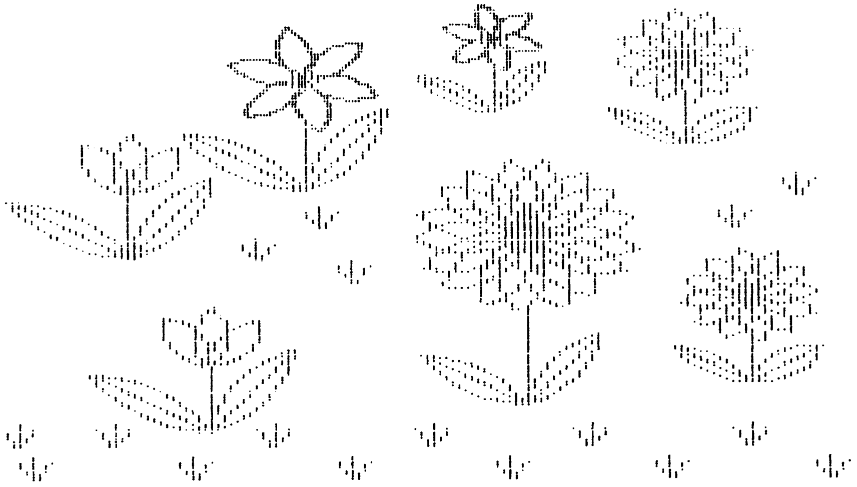


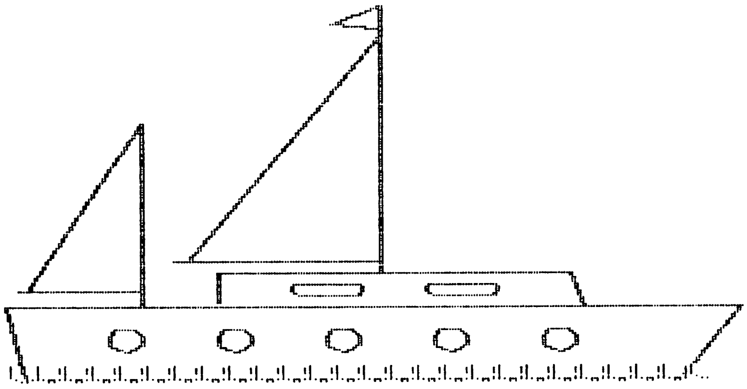




You can also combine basic shapes to make pictures of everyday objects.







Because all of these designs are pretty complicated, you have to do some thinking before you can get the turtle to draw them. Once you have your idea for a design, you will usually start by planning the mainline procedure and deciding what sub-procedures it will call. Here's how we made up the program for a train:

Joan and Maggie were doodling and drawing pictures with trapezoids. Maggie said, "Right trapezoids are great for drawing vans." She drew a trapezoid and added wheels.

Joan said, "Hey, that looks like the engine of a train!" In a short time, they had drawn a box car and a coal car. A caboose was harder to draw. Maggie sketched one, and Joan later decided to put a top on it.

Now that they knew what they wanted to make, they started to think about the mainline procedure. It was pretty obvious to break the program down like this:

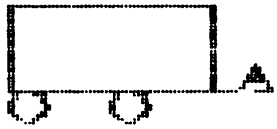
```
TO TRAIN
  ENGINE
  BOX.CAR
  COAL.CAR
  CABOOSE
END
```

The engine would need a right trapezoid and wheels. Maybe all the cars could use the same wheels. That would make things simpler. The only way the wheels could work for all the cars would be if the turtle returned to its starting place after it drew each car. "But that's just a Total Turtle Trip!" said Joan. Here's how Joan defined ENGINE:

```
TO ENGINE
  RT.TRAPEZ
  WHEELS
END

TO RT.TRAPEZ
  RT 30
  FD 30
  RT 60
  FD 40
  RT 90
  FD 25
  RT 90
  FD 53
  RT 90       (This step was necessary to get the turtle back facing 0.)
END
```

```
TO WHEELS
  RT 90
  FD 5
  CIRCLE
  FD 40          (It took a while to get this number right.)
  CIRCLE
  FD 30          (to go to the next car)
  LT 90
END
```

The box car also needed a trapezoid and wheels. The trapezoid was easy to define, but would the wheels fit? At first they looked like this:

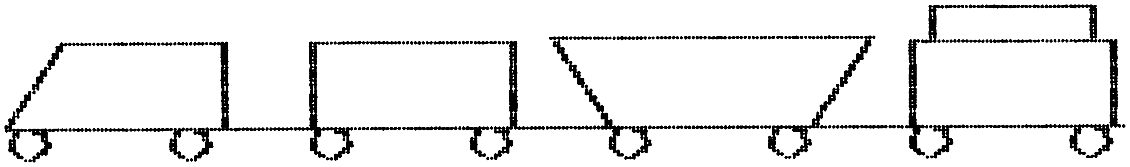


With a few adjustments, they finally looked better.

The last two cars were easy.

When the turtle drew the whole train, though, the caboose didn't fit. So Maggie added a BEGIN procedure to move the turtle over to the left of the screen.

Here is the entire TRAIN program:



```
TO TRAIN
  BEGIN
  ENGINE
  BOX.CAR
  COAL.CAR
  CABOOSE
END

TO BEGIN
  DRAW
  HT
  PU
  LT 90
  FD 140
  RT 90
  PD
END

TO ENGINE
  RT.TRAPEZ
  WHEELS
END

TO RT.TRAPEZ
  RT 30
  FD 30
  RT 60
  FD 40
  RT 90
  FD 25
  RT 90
  FD 53
  RT 90
END

TO WHEELS
  RT 90
  FD 5
  CIRCLE
  FD 40
  CIRCLE
  FD 30
  LT 90
END
```

```
TO CIRCLE
  REPEAT 18 [RT 20   FD 1.5]
END

TO  BOX.CAR
  BOX
  WHEELS
END

TO BOX
  REPEAT 2 [FD 25   RT 90   FD 50   RT 90]
END

TO  COAL.CAR
  TRAPEZ
  WHEELS
END

TO  TRAPEZ
  LT 30
  FD 30
  RT 120
  FD 80
  RT 120
  FD 30
  RT 60
  FD 50
  RT 90
END

TO  CABOOSE
  BOX
  FD 25
  RT 90
  FD 5
  LT 90
  TOP
  LT 90
  FD 5
  RT 90
  BK 25
  WHEELS
END
```

```
TO TOP
  REPEAT 2 [FD 10   RT 90   FD 40   RT 90]
END
```

PROJECTS

Here are some project ideas for each of the kinds of designs we've talked about. We are giving you outlines to help you break each program down into parts. Sometimes you will start with the shapes you want to combine; other times you will start with a whole picture in mind, as we did with the train. Different projects will work better different ways, and different people think about problems differently.

In Appendix G you will find examples of completed programs. They may help you get started on your own project.

1. Tiling

Shapes you want to use ____

____

Sketches

Chapter Six

Procedures you will need:

Mainline
Row of shapes
Move procedures
Shapes

2. Repeated Patterns

Shape or basic object (for example, flower, monogram, hat) ____________________

Sketch

Procedures you will need:

Mainline
Basic object
Shapes to make basic object
Move procedures

____
____
____
____
____
____
____
____
____
____
____
____
____
____
____

3. Circular design
Basic shapes ____________________
Sketches

Procedures you will need:

Mainline
Central design
Outer design
Shapes
Move procedures

____

____

____

____

____

____

____

____

____

____

____

____

____

4. Picture (for example, train, garden, animal, or faces)
Sketches

Procedures you will need:

Mainline
Main parts of picture (one procedure for each main part)
Basic shapes
Move procedures

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

APPENDIX

A

Summary of Logo Commands

TURTLE COMMANDS

FORWARD {number}	FD {number}	Go forward {number} steps.
BACK {number}	BK {number}	Go backward {number} steps.
RIGHT {number}	RT {number}	Rotate to the right {number} degrees.
LEFT {number}	LT {number}	Rotate to the left {number} degrees.
PENUP	PU	Put the turtle's pen up.
PENDOWN	PD	Put the turtle's pen down.
PENERASE		Put the turtle's eraser on.
PENCOLOR {number}	PC {number}	Set the turtle's pen color to given number: 0 black 1 white 2 red 3 cyan 4 purple 5 green 6 blue 7 yellow 8 orange 9 brown 10 light red 11 gray 1 12 gray 2 13 light green 14 light blue 15 gray 3
BACKGROUND {number}	BG {number}	Set the background color (as above).
SINGLECOLOR		Draw with thin line.
DOUBLECOLOR		Draw with thicker line.
HIDETURTLE	HT	Hide the turtle.
SHOWTURTLE	ST	Show the turtle.

APPENDIX

SCREEN DISPLAY

DRAW		Put the turtle in the center, facing up, and clear the screen.
SPLITSCREEN	<f3>	Split screen. The top part is for turtle drawings; the bottom part, for seeing commands.
FULLSCREEN	<f5>	Full screen. The entire screen is for turtle drawings.
TEXTSCREEN	<f1>	Text screen. The entire screen is for commands.

ARITHMETIC

+	add
−	subtract
*	multiply
/	divide

OTHER COMMANDS

REPEAT {a number} [{commands and procedures}]	Repeat what is inside the brackets the given number of times.
PRINT or PR [{a list of words}]	Print what is inside the brackets.
<CTRL> G	Stop whatever procedure is running.
<CTRL> W	Wait; it interrupts whatever is running. Press any key to continue.
STAMPCHAR “{a letter or other text character}	Place text on graphics portion of screen.

DEFINING PROCEDURES

TO {procedure name}	Enter Edit Mode to define or edit a procedure.
EDIT or ED {procedure name}	Enter Edit Mode to edit a procedure.
EDIT or ED [{a list of procedures}]	Enter Edit Mode to edit a list of procedures.
<CTRL> C	Define or redefine the procedure; return to Direct Mode.
<CTRL> G	Abort; forget the changes; return to Direct Mode.

APPENDIX

EDITING COMMANDS

Cursor Moves

CRSR ⇒	Go forward one space.
← or ⇐ CRSR	Go back one space.
⇑ CRSR	Go up a line.
CRSR ⇓	Go down a line.
<CTRL> P	Go up a line (preceding line).
<CTRL> N	Go down a line (next line).
<CTRL> A	Go to beginning of line.
<CTRL> L	Go to end of line.

Deleting and Adding

<DEL>	Delete the character to the left of the cursor.
<CTRL> D	Delete the character under the cursor.
<CTRL> K	Delete the character under the cursor and all characters to the right of it on the line. (Kill the rest of the line.)
<CTRL> 0 or <RETURN>	Open a line.

New characters are automatically inserted between the cursor and the character to its left.

WORKSPACE

POTS	Print out the titles of procedures in the workspace.
PO {procedure name}	Print out the procedure.
PO [{list of procedures}]	Print out procedures in list.
PO ALL	Print out all procedures
ERASE or ER {procedure name}	Erase the procedure named.
ERASE or ER [{list of procedures}]	Erase the list of procedures named.
GOODBYE	Erase all procedures. Clear the workspace.

MANAGING FILES

SAVE ''{file name}	Save all procedures in the workspace as a file on disk named {file name}.
SAVE "{file name} [{list of procedures}]	Save only procedures in list.
READ ''{file name}	Read the file from the disk into the workspace.
ERASEFILE ''{file name}	Erase the file from the disk.
SAVEPICT ''{file name}	Save the drawing currently on the screen in a picture file.
READPICT ''{file name}	Read in the drawing from the disk file to the screen.
ERASEPICT ''{file name}	Erase the picture file.
CATALOG	Print the names of the files on the disk.

APPENDIX

B

Glossary

ARC a part of a circle

BACK (BK) { a number } Logo command that tells the turtle to move backwards {a number} of steps
BACKGROUND (BG) {a number} Logo command that makes the background screen the color indicated by the number

CATALOG Logo command that lists all the names of the files that are currently on the disk
CENTRAL PROCESSING UNIT (CPU) the part of the computer that is in charge of the computer's operation
CLOSED SHAPE a figure that has a definite inside and outside
CURSOR the flashing square that shows where the next letter or number you type will appear on the screen
CURVE one or more arcs joined together

DEFINE A PROCEDURE teach the turtle a new command (See Edit Mode)
DEGREE FINDER a thin piece of paper or plastic with degrees marked around a circle, to be placed over the screen turtle in order to figure out the size of turns
DEGREES units to measure how big a turn is (360° is a complete turn around.)
DIRECT MODE Logo setting where the turtle carries out your commands right away
DISKETTE (DISK) a circular object of magnetic material used for storing files of information
DOUBLECOLOR Logo command that makes turtle draw thicker lines
DRAW Logo command that puts the turtle in the center of the screen, facing up, and clears the screen

EDIT (ED) {a procedure name} Logo command to enter the Edit Mode in order to write or change the procedure named
EDIT MODE Logo setting where you write, correct, or change the commands of a procedure
EDITOR another name for the Edit Mode

END Logo command that shows you have finished defining a procedure
EQUILATERAL TRIANGLE A triangle having three sides of equal length and three angles of equal size
ERASE (ER) {procedure name} Logo command that erases the procedure named from the workspace
ERASEFILE “{file name} Logo command that erases a file from the disk
ERASEPICT “{file name} Logo command that erases a picture file from the disk

FILE a set of procedures stored on disk
FORWARD (FD) {a number} Logo command that tells the turtle to move forward {a number} of steps
FULLSCREEN (<f5>) Logo command that allows you to see the entire drawing area of the monitor

GOODBYE Logo command that erases all procedures in the workspace and clears it for new work

HEXAGON a six-sided polygon
HIDETURTLE (HT) Logo command that hides the turtle from sight

INPUT 1. a device for putting information into the computer—usually a keyboard or disk drive
2. numbers or other information required by a procedure or command (For example, in the command FD 20, 20 is an input.)
INTEGER a whole number

LEFT (LT) {a number} Logo command that tells the turtle to rotate toward its left {a number} of degrees
LOGO MESSAGE a statement from the computer that explains why a command was not carried out

MACHINE LANGUAGE instructions in a code using 0's and 1's (This is the only form in which the CPU can understand instructions.)
MAINLINE PROCEDURE the procedure that controls a program and calls other procedures to do their work
MEMORY the place where a computer stores information temporarily
MONITOR a video display unit, such as a television, on which the computer can show information

NUMERAL a symbol expressing a number

OCTAGON an eight-sided polygon
OPEN SHAPE a figure that does not have a distinct inside and outside
OUTPUT 1. a device for getting information from a computer, usually a monitor or a printer
2. numbers or other information that are produced by commands in a procedure

PARALLEL LINES lines that go in the same direction but do not touch and will not cross even if they are extended indefinitely

PARALLELOGRAM a four-sided polygon with opposite sides parallel and equal in length

PENCOLOR (PC) {a number} Logo command that makes the pen draw with the color indicated by the number

PENDOWN (PD) Logo command that puts the pen down so it writes as the turtle moves forward or backward

PENERASE Logo command that puts an eraser on the turtle

PENTAGON a five-sided polygon

PENUP (PU) Logo command that puts the pen up, so it doesn't write as the turtle moves

POLYGON a closed shape with many sides

POTS Logo command that prints out the titles of the procedure in the workspace

PRINT (PR) [{a list of words}] Logo command that prints a list of words onto the monitor or the printer

PRINTOUT (PO) {procedure name} Logo command that prints out procedures in the workspace

PROCEDURE a set of Logo instructions

PROGRAM a set of procedures that work together for a specific purpose

PROMPT a symbol, usually a ?, that shows that the computer is ready for the next command

READ "{file name} Logo command that reads the file named from a disk into the workspace

READPICT "{file name} Logo command that reads the picture file from the disk onto the screen

REPEAT {a number} [{a list of procedures}] Logo command that repeats the procedures listed in the brackets the given number of times

REGULAR used with a shape, this means that all the sides of the shape are equal and all the angles are equal

RIGHT (RT) {a number} Logo command that tells the turtle to rotate to its right {a number} of degrees

RIGHT ANGLE a 90° angle or square angle

RIGHT TRIANGLE a triangle with a right angle as one of its angles

RIGHT TRAPEZOID a trapezoid with a right angle as one of its angles

RHOMBUS a parallelogram with all sides equal

ROTATE to turn in place without moving forward or backward

SAVE "{file name} Logo command that saves all the procedures in the workspace as the file named on a disk

SAVEPICT "{file name} Logo command that saves the drawing currently on the screen in a picture file on the disk

SEPTAGON a seven-sided polygon

SHOWTURTLE (ST) Logo command that makes the turtle visible on the screen

SINGLECOLOR Logo command that sets turtle back to drawing thin lines
SPLITSCREEN (<f3>) Logo command that leaves the bottom four lines for text and the rest of the screen for drawing
STAMPCHAR Logo command that prints letters and other text on the graphics screen
SUB-PROCEDURE a procedure that is one of the commands in another procedure; a procedure that is called by another procedure
SUPER-PROCEDURE a procedure that uses another procedure as one of its commands; a procedure that calls one or more procedures

TEXT the printed words displayed on the monitor
TEXTSCREEN (<f1>) Logo command that uses the whole screen for words and commands
TO {procedure name} Logo command that puts you in Edit Mode so you can define or edit a procedure
TOTAL TURTLE TRIP (TTT) the turtle's complete journey back to the same place it started, heading in the same direction (The sum of the turns will be 360° or a multiple of 360°.)
TRAPEZOID a four-sided figure with two sides that are parallel and two that are not parallel
TURTLE CLOCK a paper clock with degrees marked on it to help you decide the size of the turn you want
TURTLE PEN a paper turtle that fits over a pencil or pen and is used to act out commands on paper

WORKSPACE the temporary memory storage area in the computer
WRAPAROUND SCREEN a description of the way the screen seems to work when the turtle goes off the top and comes up from the bottom, or off one side and appears on the other, as if the screen were a continuous surface

APPENDIX

C

Message Log

Date	Logo Message	Your response (if any)

APPENDIX

Date	Logo Message	Your response (if any)

APPENDIX

Date	Logo Message	Your response (if any)

APPENDIX

D

Handling Disks

Diskettes (called disks for short) are made of magnetic material. The disk drive can write information on this material or read information from it. If you have ever used magnets, you know that they can easily become weak or useless if they are not stored carefully. The same is true of diskettes.

The magnetic material is covered almost entirely by a cardboard wrap (usually black) that protects most of the surface. It is up to you, however, to take care of the disks so that your work is not ruined.

Before the disk drive can store information on a brand-new disk, the drive has to mark a code for its brand of computer on the disk. This tells the disk drive some important information such as where the first file will be stored. This process of marking a brand-new disk is called *Initializing a disk.*

Initializing a Disk

If you are already working in Logo, you're all set to initialize a new disk. Otherwise, you need to load Logo from the Logo Language disk in the usual way (see pg. 31). Then remove the Logo disk from the drive.

1. Insert a brand-new diskette (or an old one with files that you no longer wish to keep) into the disk drive and close the door.

2. Think of a name and ID number that you'd like for your disk. You may choose any name with up to 16 characters including spaces. Your ID number must have 2 digits. Suppose you choose JAMES LOGO FILES,25. You would type in:

```
    DOS [N0:JAMES LOGO FILES,25]        <RETURN>
```

Whenever you initialize a disk you will type

```
    DOS [N0:{disk name},{ID number}]       <RETURN>
```

Notice that there is no space before or after the comma that comes between the name and ID number.
3. During the minute it takes for the disk drive to initialize your disk, you will hear strange noises. Don't worry.
4. After the disk drive stops and the red light is off, you will see the Logo *prompt* (?). Type

```
CATALOG <RETURN>
```

to see the contents of the disk. At this point you should see only the name you gave to the disk and the words 664 BLOCKS FREE. (This information tells you how much free space is available on the disk. Of course, as you save files, this number will decrease.) Your disk is now ready for you to store your files.

Note that this is the method of initializing a disk in the Logo language. You can just as well do it in BASIC (see page B-5 in the *Commodore Logo Manual*). You can store Logo and BASIC files on the same disk. This is because initializing prepares a disk to be used in any language. However, the disk can only be used on a particular computer (in your case, the Commodore 64).

Using a Disk

1. Always hold the disk carefully on the cardboard wrap. Don't ever touch the disk's surface. Fingerprints and oils can ruin the material.
2. Insert the diskette into the disk drive with the label side of the disk up. Use a gentle, smooth motion. Pushing is not necessary. Make sure the disk drive light is off.
3. Close the door of the disk drive after the diskette is inside.
4. Don't ever take a disk from the disk drive while the light is on. The light means the drive is looking for information or is writing on the disk.
5. Label all of your diskettes with a felt-tip marker—not a pen or pencil—so that you will remember what is on each one.
6. Don't eat or drink near disks or the computer. Food and especially soda can ruin the magnetic surface.
7. Do not bend disks or write on them with sharp, pointed objects.

Storing Disks

1. Keep all disks safely in their paper envelopes and in a metal or plastic box if possible. Don't just leave them in a drawer.
2. Store the disks either lying flat or standing straight up, so they won't get bent.
3. Store diskettes away from magnetic fields. (A video monitor and other appliances have magnetic fields.)
4. Keep the computer area clean so that disks won't get dirty.
5. Store disks away from heat, cold, and sunlight.

APPENDIX

E

Using a Printer

If you have a printer available to you, you will want to make copies of your procedures and pictures. It's fun to show your work to your friends and family. Sometimes it is easier to check your procedures if you can work on them away from the computer.

There are four Commodore printers that can print out Logo procedures and pictures. They are models 1515, 1525, 1526, and MPS 801. If you are using a non-Commodore printer, you can definitely get printed copies of your procedures. Check your printer manual (or with the dealer from whom you bought the printer) to find out if you can also print graphics. You may need a special printer card added to your printer before you can get Logo pictures printed.

Printing Out Procedures

1. Make sure that all the material you want to print is in your computer's workspace.
2. If that material has not already been saved on your disk, save it now.
3. Turn on the printer.
4. Type

PRINTER	This tells the computer to send its information to the printer.
PO {procedure name} or	This prints out the procedure, or
PO [{list of procedures}] or	the list of procedures, or
PO {procedures}	all the procedures in your workspace.

5. The printer will type until it has printed out all the procedures you requested.

6. As your last command, type

```
NOPRINTER
```

This tells the computer to resume sending its information to the screen only.

Printing Out Pictures

Before you can print out a picture in Commodore Logo, you must first create a picture file. There are three commands for saving and managing picture files: SAVEPICT, READPICT, and ERASEPICT. These commands work the same way SAVE, READ, and ERASE do. The difference is that SAVE creates a file of Logo procedures, while SAVEPICT saves the turtle graphics screen in two binary files.

To create a picture file, you first produce the turtle drawing you wish to save, then (while still in Direct Mode) type

```
SAVEPICT "{picture name}
```

Everything on the graphics part of the screen, except the turtle, is stored by this command.

When you look at the catalog, you will see that picture files are stored differently from your other Logo files. Pictures are stored in two files, one containing the picture, the other with information about what colors to use. You'll see your {picture name} with .PIC1 and .PIC2 appended, just as you see .LOGO appended to regular Logo files. As with .LOGO, you do not type in these letters when reading in your pictures.

READPICT "{picture name} reads in the picture that had been saved by SAVEPICT, and displays the picture on the screen. ERASEPICT "{picture name} erases the picture files.

If you are using a Commodore MPS 801 or 1525 printer, follow these steps to obtain a hard copy of your picture:

1. If your Commodore 64 is on, turn it off! Leave the disk drive and monitor on. If you're just beginning your Logo session, turn on your disk drive and monitor, but don't boot in the Logo Language Disk. Instead, go to step #2.

2. Insert the Logo Utilities Disk in the disk drive and type

```
LOAD "PRINTPICT",8
```

Wait for the red light on the drive to go out and then type

```
RUN
```

3. Soon you will get a message on the screen asking for the name of the picture that you want printed. Remove the Logo Utilities Disk and replace it with your disk with the picture files on it. Now, simply type in the name of your picture. For example, if you had saved a picture with SAVEPICT "SPIRAL, you would type

```
    SPIRAL
```

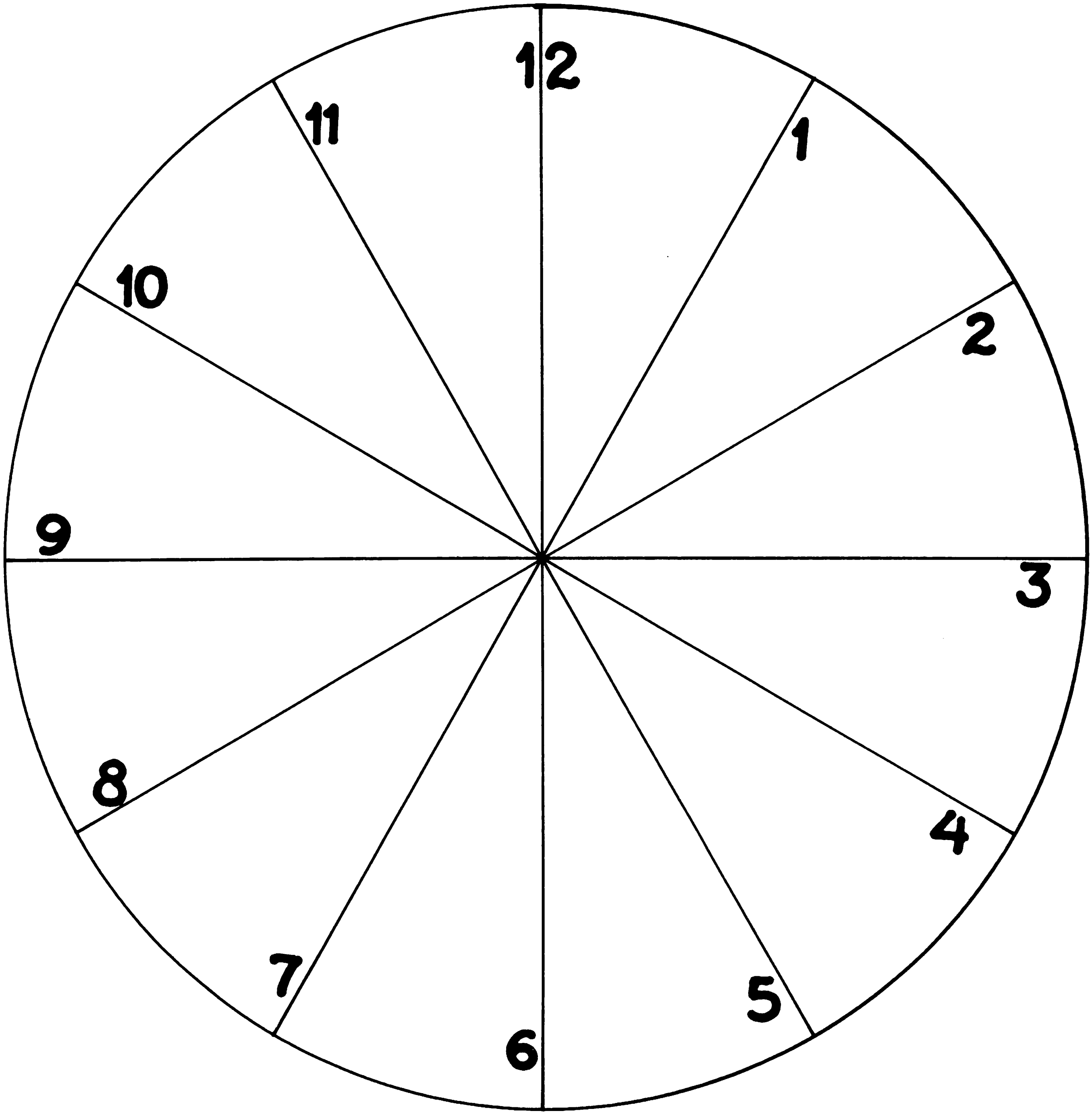
That's all there is to it. The printer will clatter away and print your picture. This process takes about 20 minutes, enough to make anybody very impatient! Fortunately, new programs have been written to shorten this time significantly—in fact, to about two minutes. The printing program on your Utility Disk was written in BASIC; these faster-working programs are in machine language. They appeared in *Commodore Microcomputers* magazine ("Two High Resolution Screen Dumps for the Commodore 64," by Steve Beats and John McKean, *Commodore Microcomputers,* Sept./Oct. 1984, pp. 82–84). Perhaps your teacher or parent can type in these programs and save them on disk for you.

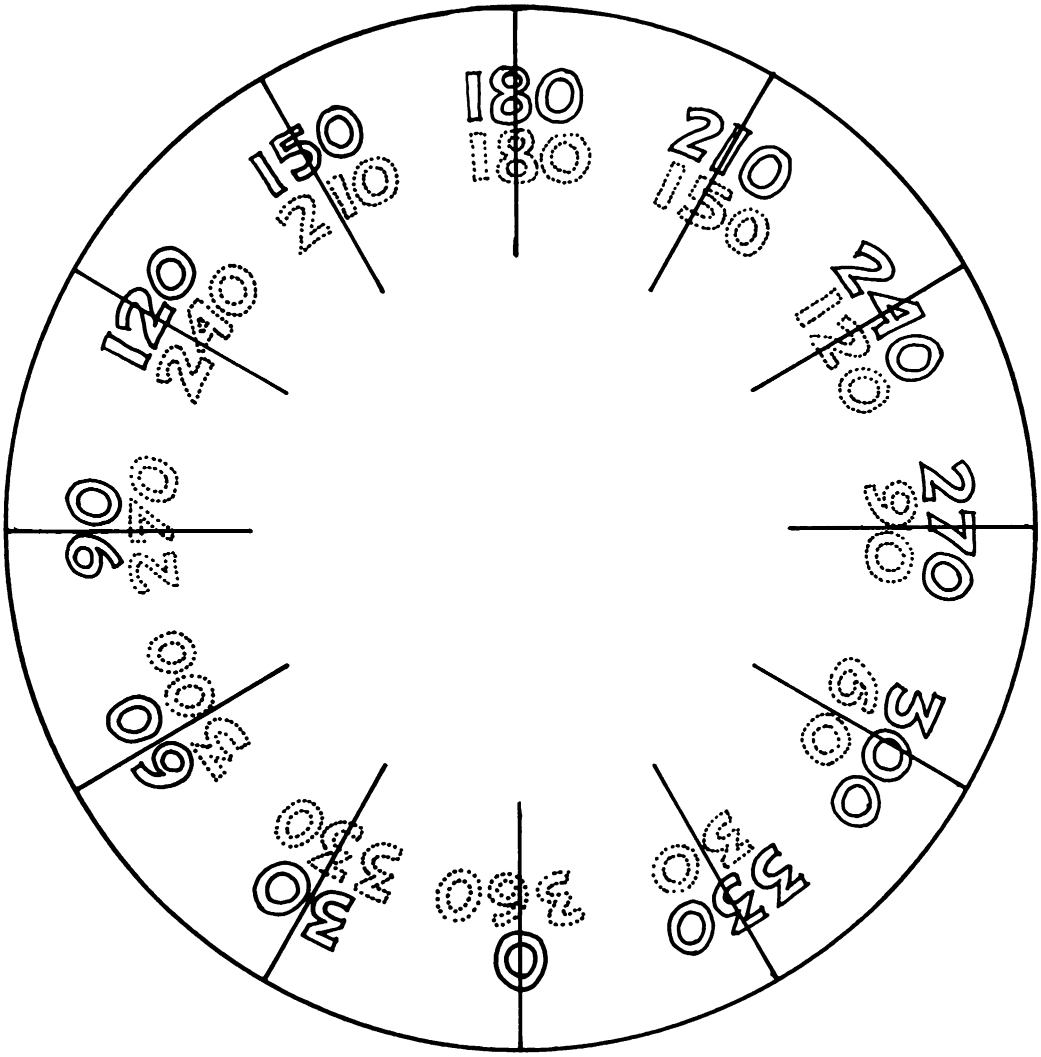
APPENDIX

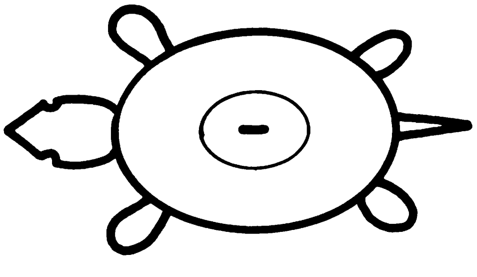
F

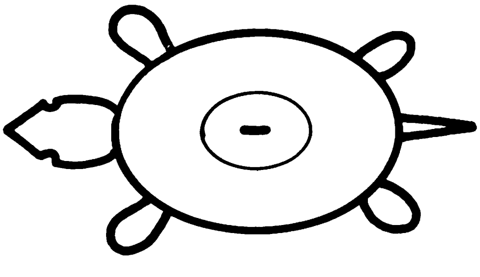
Turtle Clock and Turtle Pen

Instructions for making a Turtle Clock are on page 16; for a Turtle Pen, page 23.




180
180
210
150
240
120
270
90
300
60
330
30
0
360
30
330
60
300
90
270
120
240
150
210

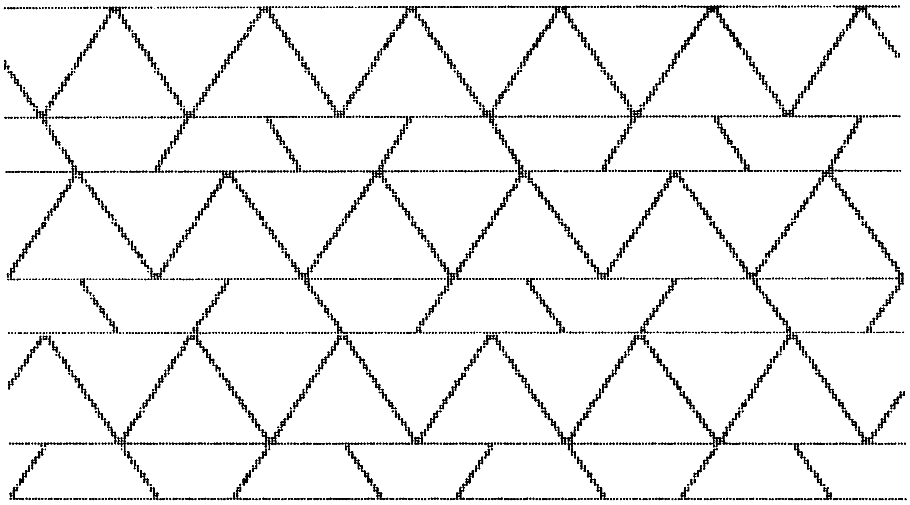




APPENDIX

G

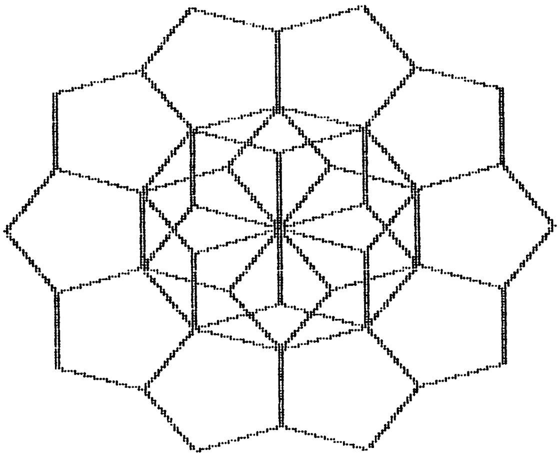
Programs



```
TO QUILT
  SETUP
  REPEAT 3 [TRAPEZ.ROW    TRI.ROW    MOVE.UP]
END

TO SETUP
  FULLSCREEN
  PU
  BK 90
  PD
  HT
END
```

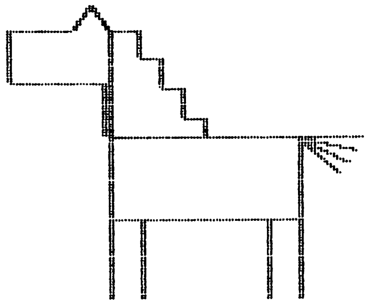
```
TO TRAPEZ.ROW
  REPEAT 4 [TRAPEZ   MOVE.LEFT]
  MOVE.UPSIDE.DOWN
  REPEAT 4 [TRAPEZ   MOVE.LEFT]
  MOVE.TO.NEXT.ROW
END

TO TRAPEZ
  RT 30
  FD 320 / 12
  RT 60
  FD 320 / 12
  RT 60
  FD 320 / 12
  RT 120
  FD 320 / 6
  RT 90
END

TO MOVE.LEFT
  LT 90
  FD 320 / 6
  FD 320 / 12
  RT 90
END

TO MOVE.UPSIDE.DOWN
  RT 30
  FD 320 / 12
  LT 210
END

TO MOVE.TO.NEXT.ROW
  LT 90
  FD 320 / 12
  LT 90
END

TO TRI.ROW
  REPEAT6[TRIANGLE   LT60   TRIANGLE   LT30   FD320 / 6   RT90]
END

TO TRIANGLE
  LT 90
  REPEAT 3 [RT 120   FD 320 / 6]
  RT 90
END

TO MOVE.UP
  RT 30
  FD 320 / 6
  LT 30
END
```

Pentagon Design



```
TO PENTAGON.DESIGN
  HT
  PENTAGON.CENTER
  MOVE
  PENTAGON.BORDER
END

TO PENTAGON.CENTER
  REPEAT 10 [PENTAGON   LT 108]
END

TO PENTAGON
  REPEAT 5 [RT 360 / 5   FD 28]
END

TO MOVE
  FD 28
  RT 72
  FD 28
  RT 144
END

TO PENTAGON.BORDER
  REPEAT 10 [PENTAGON   RT 72   FD 28   LT 108]
END
```

Horse



```
TO HORSE
  HT
  HEAD
  BODY
  LEGS
  MANE
  TAIL
END

TO HEAD
  FD 20
  LT 90
  FD 30
  RT 90
  FD 20
  RT 90
  FD 20
  LT 60
  FD 12
  RT 120
  FD 12
  RT 30
  FD 40
END

TO BODY
  LT 90
  FD 60
  RT 90
  FD 30
  RT 90
  FD 60
  RT 90
  FD 30
END
```

```
TO LEGS
  BK 30
  RT 90
  LEG
  FD 10
  LEG
  FD 40
  LEG
  FD 10
  LEG
END

TO LEG
  RT 90
  FD 30
  BK 30
  LT 90
END
```

```
TO MANE
  MANE.MOVE
  FD 7
  REPEAT 3 [LT 90   FD 7   RT 90   FD 11]
  LT 90
  FD 10
END

TO MANE.MOVE
  LT 90
  FD 30
  LT 90
  FD 30
  RT 90
END

TO TAIL
  MOVE.TAIL
  REPEAT 4 [FD 20   BK 20   RT 15]
END

TO MOVE.TAIL
  LT 90
  FD 40
  LT 90
  FD 60
END
```

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Joan Moscovitch Webb, Peter von Mertens,
and Maggie Neville Holmes

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